

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT  
SPECIAL INSTRUCTION SHEET

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# OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT CALCULATION COVER SHEET

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## 1. PURPOSE

The objective of this calculation is to determine the structural response of the waste package (WP) dropped horizontally from a specified height. The WP used for that purpose is the 21-Pressurized Water Reactor (PWR) WP. The scope of this document is limited to reporting the calculation results in terms of stress intensities. This calculation is associated with the WP design and was performed by the Waste Package Design group in accordance with the *Technical Work Plan for: Waste Package Design Description for LA* (Ref. 16). AP-3.12Q, *Calculations* (Ref. 11) is used to perform the calculation and develop the document. The sketches attached to this calculation provide the potential dimensions and materials for the 21-PWR WP design.

## 2. METHOD

The finite element calculation was performed by using the commercially available ANSYS Version (V) 5.4 and LS-DYNA V950 finite element codes. The results of this calculation were provided in terms of maximum stress intensities.

With regard to the development of this calculation, the control of electronic management of data was evaluated in accordance with AP-SV.1Q, *Control of the Electronic Management of Information* (Ref. 10). The evaluation (Addendum B of Ref. 16) determined that current work processes and procedures are adequate for the control of the electronic management of data for this activity.

## 3. ASSUMPTIONS

In the course of developing this document, the following assumptions are made regarding the structural calculation.

- 3.1 Some of the temperature-dependent material properties are not available for SB-575 N06022 (Alloy 22), SA-516 K02700 (516 carbon steel [CS]), and SA-240 S31600 (316 stainless steel [SS]). The room-temperature (20 °C) material properties are assumed for both materials. The impact of using room-temperature material properties is anticipated to be small. The rationale for this assumption is that undetermined mechanical properties of said materials will not significantly impact the results. This assumption is used in Section 5.2.
- 3.2 The Poisson's ratio of Alloy 22 is not available in literature. The Poisson's ratio of Alloy 625 (SB-443 N06625) is assumed for Alloy 22. The impact of this assumption is anticipated to be negligible. The rationale for this assumption is that the chemical compositions of Alloy 22 and Alloy 625 are similar (see Ref. 2, Table 1 and Ref. 13, p. 143, respectively). This assumption is used in Section 5.2.

- 3.3 Some of the rate-dependent material properties are not available for SB-575 N06022 (Alloy 22), SA-516 K02700 (516 carbon steel [CS]), and SA-240 S31600 (316 stainless steel [SS]). Linear approximations are assumed for both materials. The impact of using such an approximation is anticipated to be small. The rationale for this assumption is that this is the most common and accepted way of approximating these properties. This assumption is used in Section 5.3
- 3.4 Poisson's ratio is not available for 516 CS. Therefore, Poisson's ratio of cast carbon steel is assumed for 516 CS. The impact of this assumption is anticipated to be negligible. The rationale for this assumption is that the elastic constants of cast carbon steels are only slightly affected by changes in composition and structure (see Ref. 3). This assumption is used in Section 5.2.
- 3.5 The exact geometry of the loaded internals is simplified for the purpose of this calculation. The fuel baskets, thermal shunts, spent nuclear fuel, and all other internals are created as a solid cylinder with an appropriate mass value. The rationale for this assumption is to simplify the finite element representation (FER). This assumption is used in Section 5.4.
- 3.6 The elongations of Alloy 22 and 316NG SS at elevated temperatures are not available from traditional sources. However, vendor data is available (Ref. 6 and Ref. 17). The percent difference between elongations at room temperature and elevated temperatures can be normalized and applied to the data available from accepted codes. The rationale for this assumption is to be as reasonably accurate as possible. It would not be logical for the elongation values to remain constant over the range of temperatures under consideration. This assumption is used in Section 5.2.1.
- 3.7 The impact surface that the WP is to be dropped on is conservatively assumed to be perfectly rigid (unyielding). Such a material does not exist. LS-DYNA is able to simulate such a surface. The result will be that the stresses produced by this calculation will be small percentage higher than those that would result if a realistic surface were used. The rationale is that this is a conservative assumption. This assumption is used in Section 5.4.
- 3.8 Three-stage deformation characteristics are not observed in the stress-strain curves for Alloy 22 or Type 316 stainless steel (Ref. 12). However, in order to capture the peak elongations of the material from the curves, the total elongation should be conservatively reduced by 10%. The rationale for this assumption is to truncate the last portion of the curve that has decreasing slope. This assumption is used in Section 5.2.2.

## 4. USE OF COMPUTER SOFTWARE AND MODELS

### 4.1 SOFTWARE

The first finite element analysis (FEA) computer code used for this calculation is ANSYS V5.4, which is identified with the Computer Software Configuration Item (CSCI) 30040 V5.4 and was obtained from Software Configuration Management in accordance with appropriate procedures. ANSYS V5.4 is a commercially available finite element analysis code and is appropriate for structural calculations of WPs as performed in this calculation. The calculations using the ANSYS V5.4 software were executed on a Hewlett-Packard (HP) UNIX workstation, Civilian Radioactive Waste Management System (CRWMS) Management and Operating Contractor (M&O) tag number 700314. The software qualification of the ANSYS V5.4 software is summarized in the Software Qualification Report for ANSYS V5.4 (Ref. 8). Qualification of ANSYS V5.4 on the Waste Package Operations (WPO) HP UNIX workstations is documented in Reference 5. The ANSYS evaluations performed for these designs are fully within the range of the validation performed for the ANSYS V5.4 code. Access to the code was granted by the Software Configuration Secretariat in accordance with the appropriate procedures.

The second FEA code used, Livermore Software Technology Corporation (LSTC) LS-DYNA V950, is unqualified software (Ref. 7). The interim use of unqualified software such as LS-DYNA V950 (SAN: LV-2000-103, STN: 10300-950-00) in support of the site recommendation is delineated in AP-SI.1Q, *Software Management*, Section 5.11 (Ref. 9). LS-DYNA V950 qualification is being performed as part of the qualification of ANSYS V5.6 since LS-DYNA V950 is available both as a component (module) of ANSYS and as a separate finite element code. Currently, the Waste Package Department licensed LS-DYNA V950 directly from Livermore Software Technology Corporation (LSTC). Software Activity Plan (SAP) for ANSYS V5.6, SDN: 10145-SAP-5.6-00, SAN: LV-2000-103, identifies the intended use of LS-DYNA V950 prior to qualification. LS-DYNA V950 was obtained from the Configuration Management. LS-DYNA V950 is appropriate for its intended use. LS-DYNA V950 validation will be performed in accordance with AP-SI.1Q, Section 5.11. The calculations were executed on a Hewlett-Packard (HP) 9000 series workstation (CRWMS M&O tag number 117161).

The input and output files are defined in Section 8 of this document. They are located in Attachment III to this document.

### 4.2 SOFTWARE ROUTINES

The commercially available software used in this calculation is Pro/Engineer Release (R) 2000i. This software is executed on the HP workstation. Pro/Engineer R 2000i is not controlled computer software and it is not required to be qualified in accordance with Section 2.1 of AP-SI.1Q, *Software Management*.

Attachment II contains the input/output data obtained from Pro/Engineer R 2000i. The mass densities given in Section 5.2 are used as inputs to Pro/Engineer R 2000i, and corresponding masses

of WP components are obtained for the use in structural evaluations. There are no user-operated equations of mathematical models, algorithms, or numerical solution techniques applicable to the software routine since Pro/Engineer R 2000i is an engineering drawing software package and the subject mass calculations are performed by the source code, based on the dimensions of structural components and the mass density of materials. Verification of this software is accomplished by a test case, as described in Section 5.1.1. The range of input parameter values is limited to the dimensions of the structural components used in those cases; all mass calculations depend on specific geometry of the subject components. No limitations are identified on software routine applications or validity.

### 4.3 MODELS

None used.

## 5. CALCULATION

### 5.1 MASS AND GEOMETRIC DIMENSIONS OF WASTE PACKAGE

This calculation was performed using mass and geometric dimensions of the 21-PWR waste package (see pp. I-1 and I-2):

Total mass of the loaded WP = 42,277 kg

Length = 5.165 m

Outer diameter of outer shell = 1.564 m

Outer diameter of trunnion collar sleeve = 1.644 m

#### 5.1.1 Verification of Masses Obtained from Pro/Engineer R 2000i

One of the structural components of the 21-PWR WP, the extended lid reinforcement ring (ELRR), was selected for verification of the mass obtained from Pro/Engineer R 2000i. The mass of this component was determined as the product of the mass density (see Section 5.2) and the volume, using the dimensions provided in Attachment I:

$EOSLT \equiv$  Extended Outer Shell Lid Thickness = 0.025 m

$OSCL \equiv$  Outer Shell Closure Lid Outside Diameter = 1.527 m

$Gap1 \equiv$  Gap between OSCL and Outer Shell = 0.004 m

$Gap2 \equiv$  Gap between Outer Shell and Extended Outer Shell Lid = 0.004 m

$ELRRT \equiv$  Extended Lid Reinforcement Ring Thickness = 0.050 m

$ELRR \text{ Outer Diameter} = OSCL + 2 * (Gap1 - Gap2 - EOSLT) = 1.477 \text{ m}$

$ELRR \text{ Inner Diameter} = (ELRR \text{ Outer Diameter}) - 2 * ELRRT = 1.377 \text{ m}$

$ELRR \text{ Mass} = 8690 \text{ kg/m}^3 * ELRRT * ((1.477 \text{ m})^2 - (1.377 \text{ m})^2) * \pi/4 = 97.39432 \text{ kg}$

The mass obtained by the preceding calculation is identical to the mass provided on page II-20.



## 5.2 MATERIAL PROPERTIES

Material properties used in these calculations are listed in this section. Some of the temperature-dependent and rate-dependent material properties are not available for Alloy 22, 316NG SS, and 514 CS. Therefore, room-temperature density and Poisson's ratio obtained under the static loading conditions are used for Alloy 22, 316NG SS, and 514 CS. (see Assumptions 3.1 and 3.3).

SB-575 N06022 (Alloy 22) (Outer shell, outer shell lids, upper and lower trunnion collar sleeves):

- Density =  $8690 \text{ kg/m}^3$  ( $0.314 \text{ lb/in}^3$ ) (at room temperature) (Ref. 2, SB-575 Section 7.1)
- Yield strength =  $310 \text{ MPa}$  ( $45 \text{ ksi}$ ) (at room temperature) (Ref. 2, Table Y-1)  
Yield strength =  $229 \text{ MPa}$  ( $33.2 \text{ ksi}$ ) (at  $400^\circ\text{F} = 204^\circ\text{C}$ ) (Ref. 2, Table Y-1)  
Yield strength =  $222 \text{ MPa}$  ( $32.2 \text{ ksi}$ ) (at  $600^\circ\text{F} = 316^\circ\text{C}$ ) (Ref. 2, Table Y-1)
- Tensile strength =  $690 \text{ MPa}$  ( $100 \text{ ksi}$ ) (at room temperature) (Ref. 2, Table U)  
Tensile strength =  $657 \text{ MPa}$  ( $95.3 \text{ ksi}$ ) (at  $400^\circ\text{F} = 204^\circ\text{C}$ ) (Ref. 2, Table U)  
Tensile strength =  $641 \text{ MPa}$  ( $92.9 \text{ ksi}$ ) (at  $600^\circ\text{F} = 316^\circ\text{C}$ ) (Ref. 2, Table U)
- Elongation = 0.45 (at room temperature) (Ref. 2, SB-575 Table 3)
- Poisson's ratio = 0.278 (at room temperature) (Ref. 13, p. 143; see Assumption 3.2)
- Modulus of elasticity =  $206 \text{ GPa}$  (at room temperature) (Ref. 6, p. 14)  
Modulus of elasticity =  $196 \text{ GPa}$  (at  $400^\circ\text{F} = 204^\circ\text{C}$ ) (Ref. 6, p. 14)  
Modulus of elasticity =  $190 \text{ GPa}$  (at  $600^\circ\text{F} = 316^\circ\text{C}$ ) (Ref. 6, p. 14)

SA-240 S31600 (316NG SS, which is 316 SS with tightened control on carbon and nitrogen content and has the same material properties as 316 SS [see Ref. 18]) (Inner shell and inner shell lids):

- Density =  $7980 \text{ kg/m}^3$  (at room temperature) (Ref. 14, Table X1, p. 7)
- Yield strength =  $205 \text{ MPa}$  ( $30 \text{ ksi}$ ) (at room temperature) (Ref. 2, Table Y-1)  
Yield strength =  $148 \text{ MPa}$  ( $21.4 \text{ ksi}$ ) (at  $400^\circ\text{F} = 204^\circ\text{C}$ ) (Ref. 2, Table Y-1)  
Yield strength =  $130 \text{ MPa}$  ( $18.9 \text{ ksi}$ ) (at  $600^\circ\text{F} = 316^\circ\text{C}$ ) (Ref. 2, Table Y-1)
- Tensile strength =  $515 \text{ MPa}$  ( $75 \text{ ksi}$ ) (at room temperature) (Ref. 2, Table U)  
Tensile strength =  $496 \text{ MPa}$  ( $71.9 \text{ ksi}$ ) (at  $400^\circ\text{F} = 204^\circ\text{C}$ ) (Ref. 2, Table U)  
Tensile strength =  $495 \text{ MPa}$  ( $71.8 \text{ ksi}$ ) (at  $600^\circ\text{F} = 316^\circ\text{C}$ ) (Ref. 2, Table U)
- Elongation = 0.40 (at room temperature) (Ref. 2, SA-240 Table 2)
- Poisson's ratio = 0.298 (at room temperature) (Ref. 13, Figure 15, p. 755)

- Modulus of elasticity = 195 *GPa* ( $28.3 * 10^6$  *psi*) (at room temperature) (Ref. 2, Table TM-1)  
Modulus of elasticity = 183 *GPa* ( $26.5 * 10^6$  *psi*) (at 400 °F = 204 °C) (Ref. 2, Table TM-1)  
Modulus of elasticity = 174 *GPa* ( $25.3 * 10^6$  *psi*) (at 600 °F = 316 °C) (Ref. 2, Table TM-1)

SA-516 K02700 (516 CS) (Sideguides, stiffeners, and baskets):

- Density = 7850 *kg/m*<sup>3</sup> (at room temperature) (Ref. 2, SA-20/SA20M, Section 14.1)
- Yield strength = 262 *MPa* (38 *ksi*) (at room temperature) (Ref. 2, Table Y-1)  
Yield strength = 224 *MPa* (32.5 *ksi*) (at 400 °F = 204 °C) (Ref. 2, Table Y-1)  
Yield strength = 201 *MPa* (29.1 *ksi*) (at 600 °F = 316 °C) (Ref. 2, Table Y-1)
- Tensile strength = 483 *MPa* (70 *ksi*) (at room temperature) (Ref. 2, Table U)  
Tensile strength = 483 *MPa* (70 *ksi*) (at 400 °F = 204 °C) (Ref. 2, Table U)  
Tensile strength = 483 *MPa* (70 *ksi*) (at 600 °F = 316 °C) (Ref. 2, Table U)
- Elongation = 0.21 (at room temperature) (Ref. 2, SA-516 Table 2)
- Poisson's ratio = 0.3 (at room temperature) (Ref. 3, p. 374) (see Assumption 3.4)
- Modulus of elasticity = 203 *GPa* ( $29.5 * 10^6$  *psi*) (at room temperature) (Ref. 2, Table TM-1)  
Modulus of elasticity = 191 *GPa* ( $27.7 * 10^6$  *psi*) (at 400 °F = 204 °C) (Ref. 2, Table TM-1)  
Modulus of elasticity = 184 *GPa* ( $26.7 * 10^6$  *psi*) (at 600 °F = 316 °C) (Ref. 2, Table TM-1)

### 5.2.1 Calculations for Elevated-Temperature Material Properties

The values for elongation at elevated temperatures are not listed in conventional listings such as American Society for Testing and Materials (ASTM) Standards or American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code. However, the elongation values at elevated temperatures are available from vendor data. This vendor data will be used in a *qualitative* manner (see Assumption 3.6).

For Alloy 22, the vendor data shows a 5.7% increase in elongation values between 400 °F and room temperature and a 13% increase between 600 °F and room temperature (Ref. 6).

Therefore the elongation values for Alloy 22 at elevated temperatures will be as follows:

$$\text{Elongation}_{400\text{ }^{\circ}\text{F}} = 0.45 * 1.057 = 0.48$$

$$\text{Elongation}_{600\text{ }^{\circ}\text{F}} = 0.45 * 1.13 = 0.51$$

For SS 316, the vendor data shows a 25% decrease in elongation values between 400 °F and room temperature and a 29% decrease between 600 °F and room temperature (Ref. 17).

Therefore the elongation values for SS 316 at elevated temperatures will be as follows:

$$\text{Elongation}_{400\text{ }^{\circ}\text{F}} = 0.40 * (1 - 0.25) = 0.30$$

$$\text{Elongation}_{600\text{ }^{\circ}\text{F}} = 0.40 * (1 - 0.29) = 0.28$$

Since the components made of SA-516 will not be analyzed for stresses, its elongation is not needed at elevated temperatures. The SA-516 components are only needed for their density.

### 5.2.2 Calculations for True Measures of Ductility

The material properties in Sections 5.2 and 5.2.1 refer to engineering stress and strain definitions:

$$s = \frac{P}{A_0} \text{ and } e = \frac{L - L_0}{L_0}$$

Where  $P$  stands for the force applied during static tensile test,  $L$  is the deformed-specimen length, and  $L_0$  and  $A_0$  are original length and cross-sectional area of specimen, respectively. It is generally accepted that the engineering stress-strain curve does not give a true indication of the deformation characteristics of a material during the plastic deformation since it is based entirely on the original dimensions of the specimen. Therefore, the LS-DYNA V950 finite element code requires input in terms of true stress and strain definitions:

$$\sigma = \frac{P}{A} \text{ and } \epsilon = \ln\left(\frac{L}{L_0}\right)$$

The relationships between the true stress and strain definitions and engineering stress and strain definitions can be readily derived based on constancy of volume ( $A_0 * L_0 = A * L$ ) and strain homogeneity during plastic deformation:

$$\sigma = s * (1 + e) \text{ and } \epsilon = \ln(1 + e)$$

These expressions are applicable only in the hardening region of stress-strain curve that is limited by the onset of necking.

The following parameters are used in the subsequent calculations:

$s_y \approx \sigma_y \equiv$  yield strength

$s_u \equiv$  engineering tensile strength

$\sigma_u \equiv$  true tensile strength

$e_y \approx \varepsilon_y \equiv$  strain corresponding to yield strength

$e_u \equiv$  engineering strain corresponding to tensile strength (engineering uniform strain)

$\varepsilon_u \equiv$  true strain corresponding to tensile strength (true uniform strain)

In absence of the uniform strain data in available literature, it needs to be estimated based on stress-strains curves and elongation (strain corresponding to rupture of the tensile specimen).

The stress-strain curves for Alloy 22, 316 SS and 316NG SS do not manifest three-stage deformation characteristics (Ref. 12). Therefore, the elongation, reduced by 10% for the sake of conservatism (Assumption 3.8), can be used in place of uniform strain.

In the case of Alloy 22 ( $e_u = 0.9 * elongation = 0.41$  at room temperature), the true measures of ductility are

$$\varepsilon_u = \ln(1 + e_u) = \ln(1 + 0.41) = 0.34$$

$$\sigma_u = s_u * (1 + e_u) = 690 * (1 + 0.41) = 973 \text{ MPa}$$

400 °F (204 °C) Alloy 22

$$\varepsilon_u = \ln(1 + e_u) = \ln(1 + 0.43) = 0.36$$

$$\sigma_u = s_u * (1 + e_u) = 657 * (1 + 0.43) = 940 \text{ MPa}$$

600 °F (316 °C) Alloy 22

$$\varepsilon_u = \ln(1 + e_u) = \ln(1 + 0.46) = 0.38$$

$$\sigma_u = s_u * (1 + e_u) = 641 * (1 + 0.46) = 936 \text{ MPa}$$

For 316NG SS at room temperature,  $e_u = 0.9 * elongation = 0.36$ , therefore:

$$\varepsilon_u = \ln(1 + e_u) = \ln(1 + 0.36) = 0.31$$

$$\sigma_u = s_u * (1 + e_u) = 515 * (1 + 0.36) = 700 \text{ MPa}$$

400 °F (204 °C) SS 316NG

$$\varepsilon_u = \ln(1 + e_u) = \ln(1 + 0.27) = 0.24$$

$$\sigma_u = s_u * (1 + e_u) = 496 * (1 + 0.27) = 630 \text{ MPa}$$

600 °F (316 °C) SS 316NG

$$\varepsilon_u = \ln(1 + e_u) = \ln(1 + 0.26) = 0.23$$

$$\sigma_u = s_u * (1 + e_u) = 495 * (1 + 0.26) = 624 \text{ MPa}$$

### 5.2.3 Calculations for Tangent Moduli

As previously discussed, the results of this simulation are required to include elastic and plastic deformations for Alloy 22, 516 CS, and 316NG SS. When the materials are driven into the plastic range, the slope of stress-strain curve continuously changes. Thus, a simplification for this curve is needed to incorporate plasticity into the Finite Element Representation (FER). A standard approximation commonly used in engineering is to use a straight line that connects the yield point and the tensile strength point of the material. The parameters used in the subsequent calculations in addition to those defined in Section 5.2.2 are modulus of elasticity ( $E$ ) and tangent modulus ( $E_t$ ). The tangent (hardening) modulus represents the slope of the stress-strain curve in the plastic region.

In the case of Alloy 22, the strain corresponding to the yield strength is:

$$\epsilon_{y,rt} = \sigma_y / E = 310 * 10^6 / 206 * 10^9 = 0.0015 \text{ (see Section 5.2.1)}$$

Hence, the tangent modulus at room temperature is:

$$E_{t,rt} = (\sigma_{u,rt} - \sigma_{y,rt}) / (\epsilon_{u,rt} - \epsilon_{y,rt}) = (0.973 - 0.310) / (0.34 - 0.0015) = 2.0 \text{ GPa (see Section 5.2, 5.2.1, and 5.2.2)}$$

For Alloy 22 at 400 °F (204 °C)

$$E_{t,400°F} = (\sigma_{u,400°F} - \sigma_{y,400°F}) / (\epsilon_{u,400°F} - \sigma_{y,400°F} / E_{400°F}) = (0.940 - 0.229) / (0.36 - 229 / 196e3) = 2.0 \text{ GPa (see Section 5.2, 5.2.1, and 5.2.2)}$$

For Alloy 22 at 600 °F (316 °C)

$$E_{t,600°F} = (\sigma_{u,600°F} - \sigma_{y,600°F}) / (\epsilon_{u,600°F} - \sigma_{y,600°F} / E_{600°F}) = (0.936 - 0.222) / (0.38 - 222 / 190e3) = 1.9 \text{ GPa (see Section 5.2, 5.2.1, and 5.2.2)}$$

Similarly, for 316NG SS at room temperature:

$$E_{t,rt} = (\sigma_{u,rt} - \sigma_{y,rt}) / (\epsilon_{u,rt} - \sigma_{y,rt} / E_{rt}) = (0.700 - 0.205) / (0.31 - 205 / 195e3) = 1.6 \text{ GPa (see Section 5.2, 5.2.1, and 5.2.2)}$$

For 316NG SS at 400 °F (204 °C)

$$E_{t,400°F} = (\sigma_{u,400°F} - \sigma_{y,400°F}) / (\epsilon_{u,400°F} - \sigma_{y,400°F} / E_{400°F}) = (0.630 - 0.148) / (0.24 - 148 / 183e3) = 2.0 \text{ GPa (see Section 5.2, 5.2.1, and 5.2.2)}$$

For 316NG SS at 600 °F (316 °C)

$$E_{t,600°F} = (\sigma_{u,600°F} - \sigma_{y,600°F}) / (\epsilon_{u,600°F} - \sigma_{y,600°F} / E_{600°F}) = (0.624 - 0.130) / (0.23 - 130 / 174e3) = 2.2 \text{ GPa (see Section 5.2, 5.2.1, and 5.2.2)}$$

The tangent modulus for 516 CS was not calculated at any temperature. This is because none of the parts made from this material are critical. The density is the most important physical property for these parts. The overall mass comparison will validate the density value chosen for 516 CS (see Section 6.0).

### 5.3 INITIAL VELOCITY OF WASTE PACKAGE

To reduce the computer execution time while preserving all features of the problem relevant to the structural calculation, the WP is set in a position just before impact and given an appropriate initial velocity, as can be seen in Figure 1.

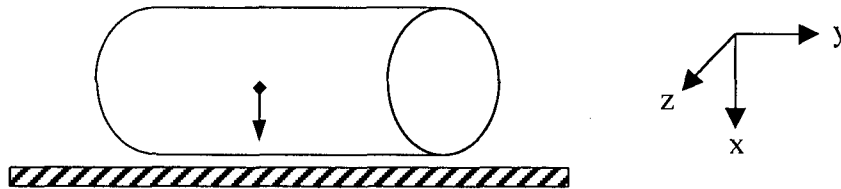


Figure 1. Horizontal Drop Geometry

Using the following parameters:

$g \equiv$  acceleration due to gravity =  $9.81 \text{ m/s}^2$

$S \equiv$  Drop Height =  $2.4 \text{ m}$  (Ref. 1)

and Newton's equation of motion:

$$V^2 = V_0^2 + 2a(S - S_0)$$

Substituting values in yields

$$V^2 = 0^2 + 2*(9.81 \text{ m/s}^2)*(2.4 \text{ m}), \text{ which reduces to}$$
$$V = 6.86 \text{ m/s}$$

## 5.4 FINITE ELEMENT REPRESENTATION

A full three-dimensional (3-D) FER of the WP was developed in ANSYS V5.4 using the dimensions provided in Attachment I. The FER was created with a radial gap of 5 *mm* between the inner and outer shells. The same gap was used between the internals and the inner shell. The initial orientation of the inner shell maintains a 5 *mm* gap around the circumference of the shell. The document establishing a gap is Ref. 4. Reference 4 states a maximum gap of 4 *mm*. However, this calculation was performed in the anticipation of a change to 5 *mm*.

The internal structure of the WP was simplified. The internal components of the Inner Shell (fuel basket, thermal shunts, side guides, spent nuclear fuel, etc.) were represented using solid elements as a solid cylinder (Assumption 3.5). This significantly lowered the number of contacts within the FER while still maintaining the proper mass needed for the computer run.

The target surface was conservatively assumed to be unyielding (Assumption 3.7). This was accomplished using the \*RIGIDWALL command within LS-DYNA. This command creates an invisible rigid wall within LS-DYNA. All nodes are slaves to the RIGIDWALL, and the RIGIDWALL is immovable.

The mesh of the FER was appropriately generated and refined in the contact region according to standard engineering practice. Thus, the accuracy of the results of this calculation is deemed acceptable.

The initial drop height of the WP was reduced to 0.01 m before impact and the WP was given an initial velocity equal to 6.86 m/s (see Section 5.3).

The FER was then used in LS-DYNA V950 to perform the transient dynamic analysis for the 21-PWR Waste Package horizontal drop.

## 6. RESULTS

This document may be affected by technical product input information that requires confirmation. Any changes to the document that may occur as a result of completing the confirmation activities will be reflected in subsequent revisions. The status of the technical product input information quality may be confirmed by review of the DIRS database.

Attachment III includes the input files and results files that show execution of the programs occurred correctly. The stresses were reported via plots that have been made interactively using the postprocessor LSPOST. The stresses were recorded every 0.001 seconds after impact. The stresses in all components peaked between 0.011 and 0.024 seconds. However, the solution was allowed to reach 0.030 seconds to ensure that all stresses had climaxed.

The results file, d3hsp (Attachment III), lists the calculated masses used by LS-DYNA. The sum of the masses of the WP equals 41,500 kg, with the mass of the loaded WP 42,277 kg from Section 5.1. However, the top and bottom lids of the inner shell were thinned to 50 mm from 95 mm. The change in mass would be to lessen this number by 1,320 kg, to 40,957 kg.  $((1.530\text{ m})^2 * \pi/4 * 0.090\text{ m} * 7980\text{ kg/m}^3 = 1,320\text{ kg})$  The percent difference in mass would then be ~1.3%. However, this difference is on the positive side, and thus considered to be conservative and negligible.

It should also be noted that an extra section was added. A "Crush Ring" was added in-between the Support Ring and the Inner Shell. This Crush Ring absorbs energy that normally would be transferred to the Inner Shell if it were not present. Thus, it effectively lowers the stresses in the Inner Shell. This Ring is not shown on the drawings in Attachment I since it was added as a result of this calculation. This addition also changes some dimensions, which would account for some of the differences in total mass.

The following pages contain figures that show various parts at states of maximum stress. These start on the next page with Figure 2, which shows the maximum stress in the lower trunnion collar at room temperature.



Time = 0.0069997  
Contours of Maximum Shear Stress  
min=703221, at elem# 57561  
max=4.57639e+08, at elem# 59343

Fringe Levels

4.576e+08  
4.119e+08  
3.663e+08  
3.206e+08  
2.749e+08  
2.292e+08  
1.835e+08  
1.378e+08  
9.209e+07  
4.640e+07  
7.032e+05

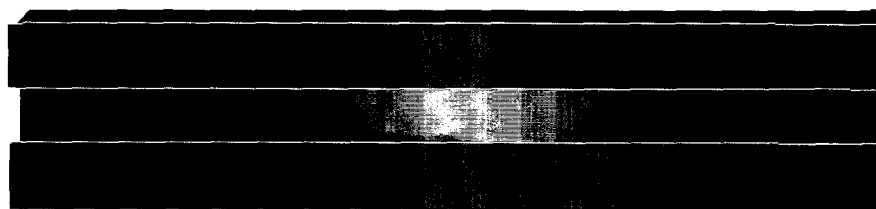


Figure 2. Collar Maximum Stresses at Room Temperature

All of the stresses that are reported in the legends of the plots are Tresca Stresses or Maximum Shear Stresses. The units are Pascals. Figure 2 shows that the maximum stresses in the lower trunnion collar are 458 MPa at 0.007 seconds.

Figure 3 may be found on the next page. It shows the maximum stress in the same part, but at 400 degrees Fahrenheit.

Time = 0.0074997  
Contours of Maximum Shear Stress  
min=899651, at elem# 55851  
max=4.20363e+08, at elem# 59343

Fringe Levels

4.204e+08  
3.784e+08  
3.365e+08  
2.945e+08  
2.526e+08  
2.106e+08  
1.687e+08  
1.267e+08  
8.479e+07  
4.285e+07  
8.997e+05

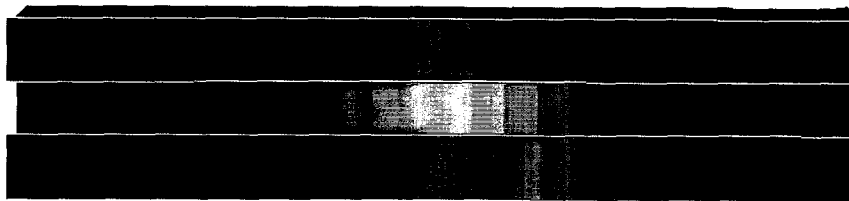


Figure 3. Collar Maximum Stresses at 400 °F

Figure 3 shows that the maximum shear stress in the lower trunnion collar is 420 MPa at 0.0075 seconds. This is slightly lower than the room temperature value, which is to be expected.

Figure 4 may be found on the next page. It shows the maximum stress in the same part, but at 600 degrees Fahrenheit.

Time = 0.0074999  
Contours of Maximum Shear Stress  
min=906635, at elem# 55746  
max=3.98669e+08, at elem# 59784

Fringe Levels

3.987e+08  
3.589e+08  
3.191e+08  
2.793e+08  
2.396e+08  
1.998e+08  
1.600e+08  
1.202e+08  
8.046e+07  
4.068e+07  
9.066e+05

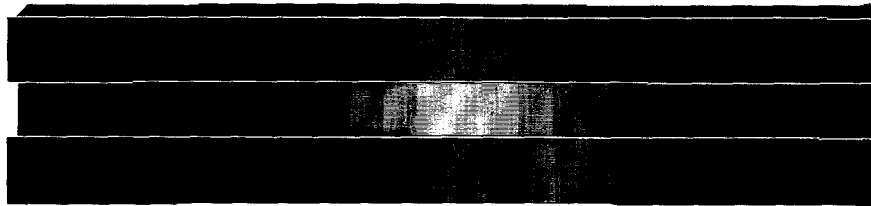


Figure 4. Collar Maximum Stresses at 600 °F

Figure 4 shows that the maximum shear stress in the lower trunnion collar is 399 MPa at 0.0075 seconds. This is slightly lower than the 400 °F value, which is to be expected.

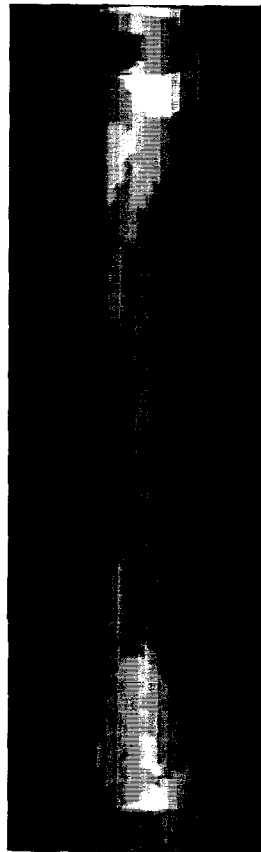
Figure 5 may be found on the next page. It shows the maximum stress in the outer shell at room temperature.

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Time = 0.0059999  
Contours of Maximum Shear Stress  
min=3.26944e+06, at elem# 37004  
max=3.71139e+08, at elem# 45062



Fringe Levels

3.711e+08  
3.344e+08  
2.976e+08  
2.608e+08  
2.240e+08  
1.872e+08  
1.504e+08  
1.136e+08  
7.684e+07  
4.006e+07  
3.269e+06

Figure 5. Outer Shell Maximum Stresses at Room Temperature

Figure 5 figure shows that the maximum shear stress in the outer shell is 371 MPa at 0.006 seconds.

Figure 6 may be found on the next page. It shows the maximum stress in the same part, but at 400 degrees Fahrenheit.

Time = 0.0064997  
Contours of Maximum Shear Stress  
min=2.65397e+06, at elem# 45004  
max=3.54334e+08, at elem# 45723



Fringe Levels

3.543e+08  
3.192e+08  
2.840e+08  
2.488e+08  
2.137e+08  
1.785e+08  
1.433e+08  
1.082e+08  
7.299e+07  
3.782e+07  
2.654e+06

Figure 6. Outer Shell Maximum Stresses at 400 °F

Figure 6 shows that the maximum shear stress in the outer shell is 354 MPa at 0.0065 seconds. This is slightly lower than the room temperature value, which is to be expected.

Figure 7 may be found on the next page. It shows the maximum stress in the same part, but at 600 degrees Fahrenheit.

Time = 0.0065  
Contours of Maximum Shear Stress  
min=2.96833e+06, at elem# 36943  
max=3.36346e+08, at elem# 45723



Fringe Levels

3.363e+08  
3.030e+08  
2.697e+08  
2.363e+08  
2.030e+08  
1.697e+08  
1.363e+08  
1.030e+08  
6.964e+07  
3.631e+07  
2.968e+06

Figure 7. Outer Shell Maximum Stresses at 600 °F

Figure 7 shows that the maximum shear stress in the outer shell is 336 MPa at 0.0065 seconds. This is slightly lower than the 400 °F value, which is to be expected.

Figure 8 may be found on the next page. It shows the maximum stress in the inner shell at room temperature.

Time = 0.0074997  
Contours of Maximum Shear Stress  
min=990966, at elem# 24819  
max=2.77584e+08, at elem# 15274

Fringe Levels

2.776e+08  
2.499e+08  
2.223e+08  
1.946e+08  
1.669e+08  
1.393e+08  
1.116e+08  
8.397e+07  
5.631e+07  
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9.910e+05

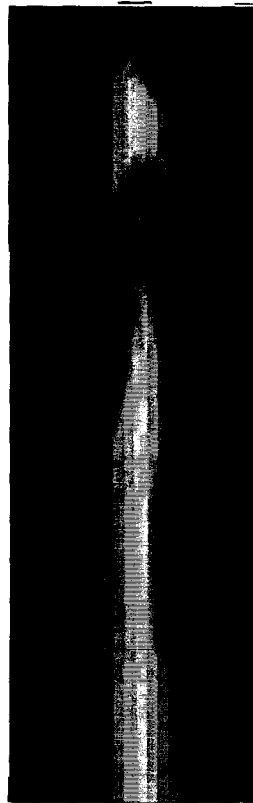


Figure 8. Inner Shell Maximum Stresses at Room Temperature

Figure 8 shows that the maximum shear stress in the inner shell is 278 MPa at 0.0075 seconds.

Figure 9 may be found on the next page. It shows the maximum stress in the same part, but at 400 degrees Fahrenheit.

Time = 0.005998  
Contours of Maximum Shear Stress  
min=2.31875e+06, at elem# 17325  
max=2.99004e+08, at elem# 18389

Fringe Levels

2.990e+08  
2.693e+08  
2.397e+08  
2.100e+08  
1.803e+08  
1.507e+08  
1.210e+08  
9.132e+07  
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3.199e+07  
2.319e+06

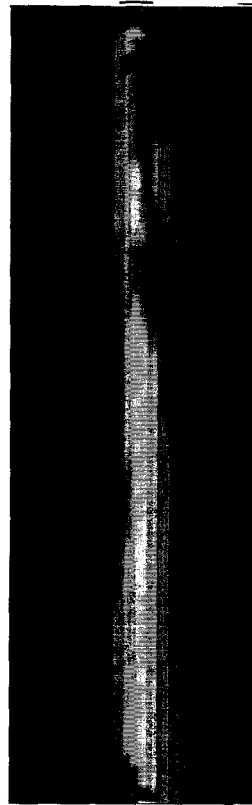


Figure 9. Inner Shell Maximum Stresses at 400 °F

Figure 9 shows that the maximum shear stress in the inner shell is 299 MPa at 0.006 seconds. This is slightly higher than the room temperature value, which is to be expected due to 316NG SS elongation properties at elevated temperatures.

Figure 10 may be found on the next page. It shows the maximum stress in the same part, but at 600 degrees Fahrenheit.



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Time = 0.006  
Contours of Maximum Shear Stress  
min=2.7388e+06, at elem# 16516  
max=3.11261e+08, at elem# 15922

Fringe Levels

3.113e+08  
2.804e+08  
2.496e+08  
2.187e+08  
1.879e+08  
1.570e+08  
1.262e+08  
9.530e+07  
6.445e+07  
3.359e+07  
2.739e+06

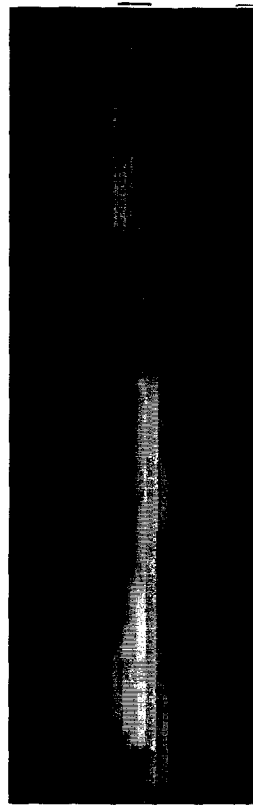


Figure 10. Inner Shell Maximum Stresses at 600 °F

Figure 10 shows that the maximum shear stress in the inner shell is 311 MPa at 0.006 seconds. This is slightly higher than the 400 °F value, which is to be expected due to 316NG SS elongation properties at elevated temperatures.

## 7. REFERENCES

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## 8. ATTACHMENTS

Attachment I (3 pages): Design sketches (*21-PWR Waste Package Configurations for Site Recommendation* [SK-0175 REV 02, two sheets], and *21-PWR Waste Package Weld Configuration* [SK-0191 REV 00])

Attachment II (37 pages): Structural component masses of 21-PWR Waste Package

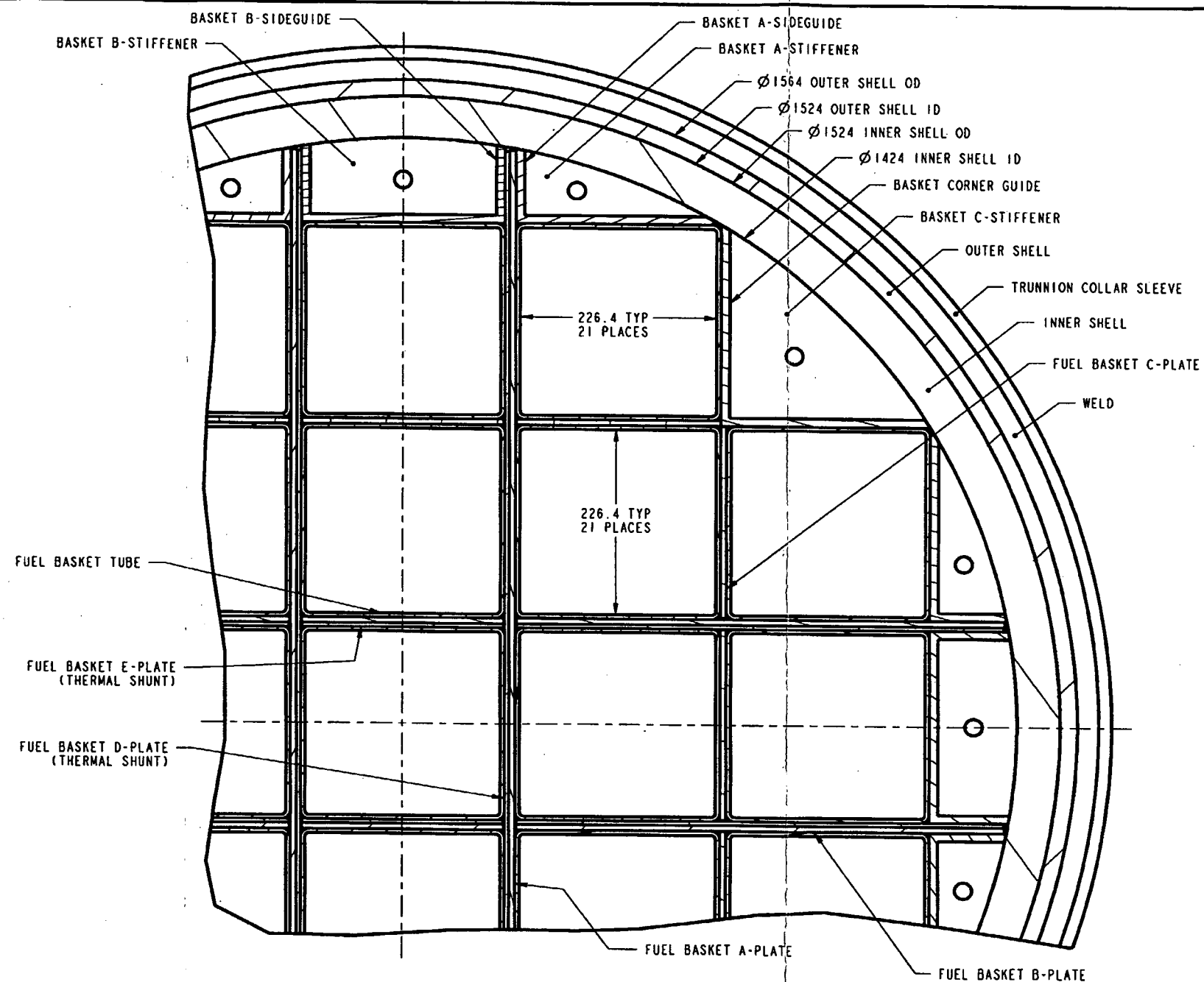
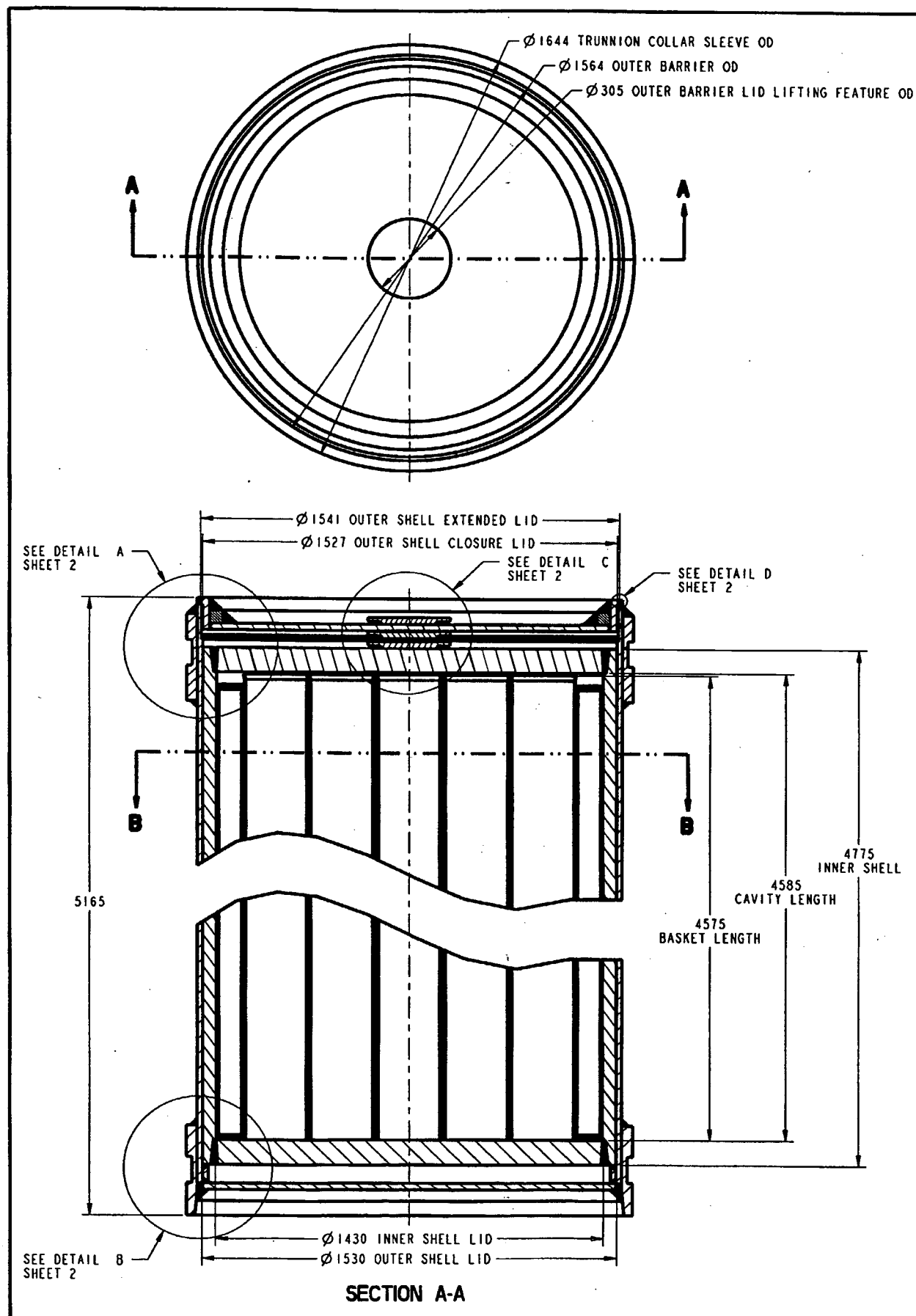
Attachment III (on compact disc): contains electronic files (see Table 8-1 for a complete list). The \*.k files are input files for LS-DYNA at the three temperatures and they call the \*.inc files. The d3hspt files are the LS-DYNA output files at the three temperatures.

Table 8-1 provides a list of attachments submitted in the form of electronic files (compact disc) in Attachment III.

Table 8-1. List of Attachments Submitted in the Form of Electronic Files in Attachment III

Description	Date	Time	Size
hdrop.inp	11/13/2000	11:06 am	18 KB
d3hspt1	11/01/2000	10:03 am	19,691 KB
d3hspt2	11/01/2000	10:25 am	19,681 KB
d3hspt3	11/01/2000	10:21 am	19,675 KB
elist.inc	11/01/2000	10:02 am	5,187 KB
nlist.inc	11/01/2000	10:02 am	4,944 KB
hdt1.k	11/01/2000	10:04 am	2 KB
hdt2.k	11/01/2000	10:25 am	2 KB
hdt3.k	11/01/2000	10:20 am	2 KB

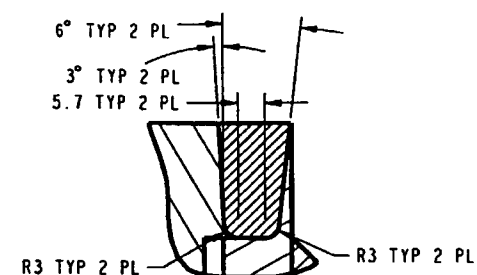
NOTE: The file sizes may vary with operating system.



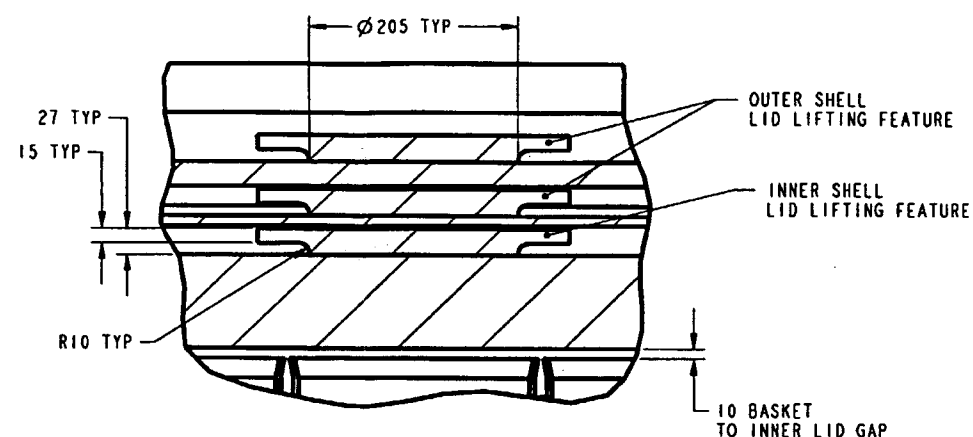
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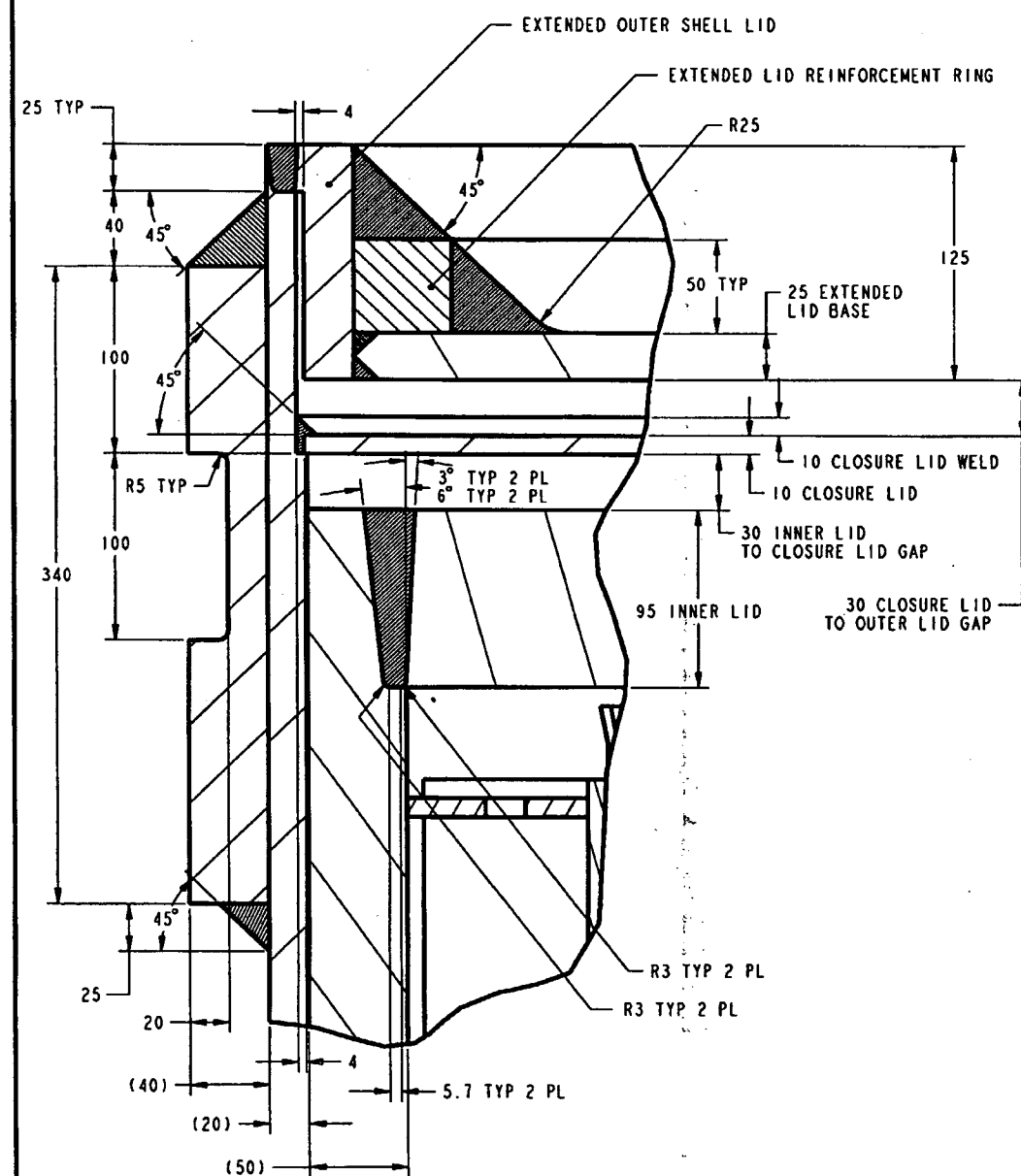
21-PWR WASTE PACKAGE CONFIGURATIONS FOR SITE RECOMMENDATION		
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SKETCHED BY:	BRYAN HARKINS	
DATE:	01/26/00	
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**DETAIL D**



**DETAIL C**

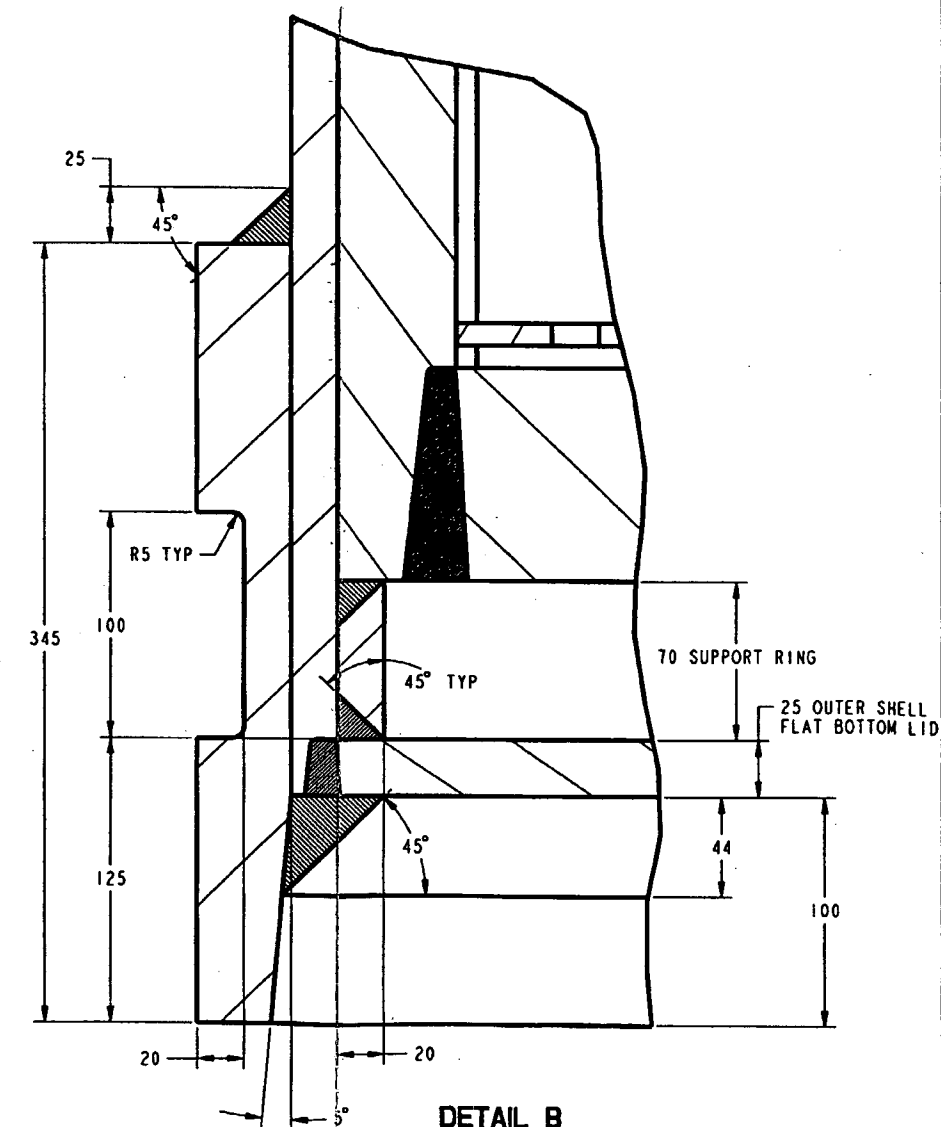


**DETAIL A**

21-PWR WASTE PACKAGE ASSEMBLY WITH STAINLESS STEEL/BORON PLATES

# 21-PWR CONTROL ROD WASTE PACKAGE ASSEMBLY WITH CARBON STEEL PLATES

COMPONENT NAME	MATERIAL	THICKNESS	MASS (KG)	QTY ROD
BASKET A-SIDEGUIDE	SA-516 K02700	10	27	32
BASKET A-STIFFENER	SA-516 K02700	10	0.72	64
BASKET B-SIDEGUIDE	SA-516 K02700	10	36	16
BASKET B-STIFFENER	SA-516 K02700	10	1.5	32
BASKET C-STIFFENER	SA-516 K02700	10	2.3	32
BASKET CORNERGUIDE	SA-516 K02700	10	42	16
FUEL BASKET A-PLATE	NEUTRONIT A 978	7	85	8
	#SA-516 K02700	#7	#86	#8
FUEL BASKET B-PLATE	NEUTRONIT A 978	7	85	8
	#SA-516 K02700	#7	#86	#8
FUEL BASKET C-PLATE	NEUTRONIT A 978	7	44	16
	#SA-516 K02700	#7	#45	#16
FUEL BASKET D-PLATE	SB-209 A96061 T4	5	21	8
FUEL BASKET E-PLATE	SB-209 A96061 T4	5	21	8
FUEL BASKET TUBE	SA-516 K02700	5	164	21
INNER SHELL	SA-240 S31600	50	8709	1
INNER SHELL LID	SA-240 S31600	95	1200	2
INNER LID LIFTING FEATURE	SA-240 S31600	27	12	1
OUTER SHELL	SB-575 N06022	20	4193	1
EXTENDED OUTER SHELL LID	SB-575 N06022	25	132	1
EXTENDED OUTER SHELL LID BASE	SB-575 N06022	25	366	1
OUTER LID LIFTING FEATURE	SB-575 N06022	27	13	2
EXTENDED LID REINFORCEMENT RING	SB-575 N06022	50	97	1
OUTER SHELL FLAT CLOSURE LID	SB-575 N06022	10	159	1
OUTER SHELL FLAT BOTTOM LID	SB-575 N0-6022	25	396	1
UPPER TRUNNION COLLAR SLEEVE	SB-575 N06022	40	507	1
LOWER TRUNNION COLLAR SLEEVE	SB-575 N06022	40	497	1
INNER SHELL SUPPORT RING	SB-575 N06022	20	41	1
TOTAL ALLOY 22 WELDS	SFA-5.14 N06022	-	249	**
TOTAL 316 WELDS	SFA-5.9 S31680	-	128	**
WASTE PACKAGE ASSEMBLY	-	-	26035	1
	-	-	#26059	#1
PWR FUEL ASSEMBLY	-	-	773.4*	21
WP ASSEMBLY WITH SNF	-	-	42277	1
	-	-	#42301	#1



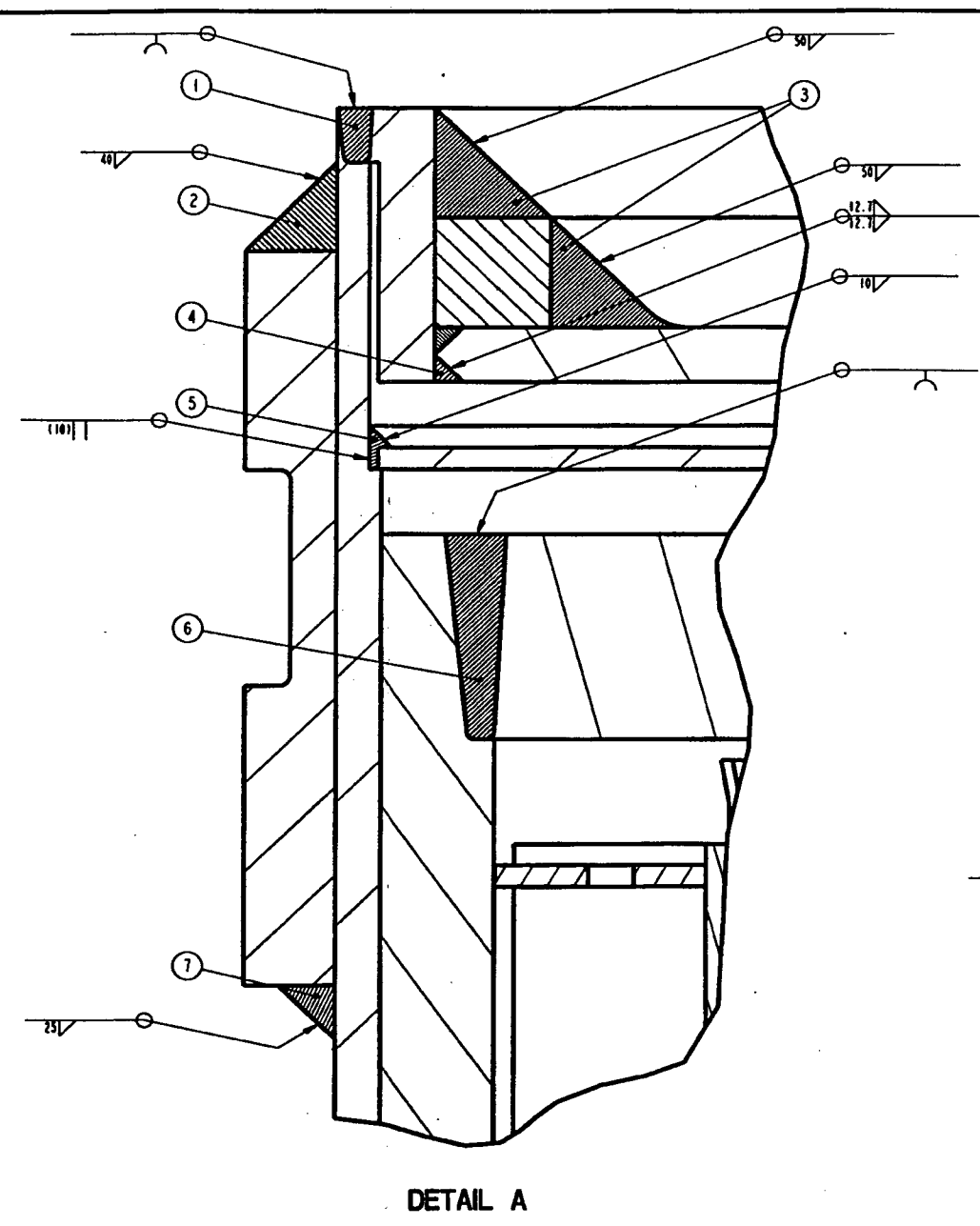
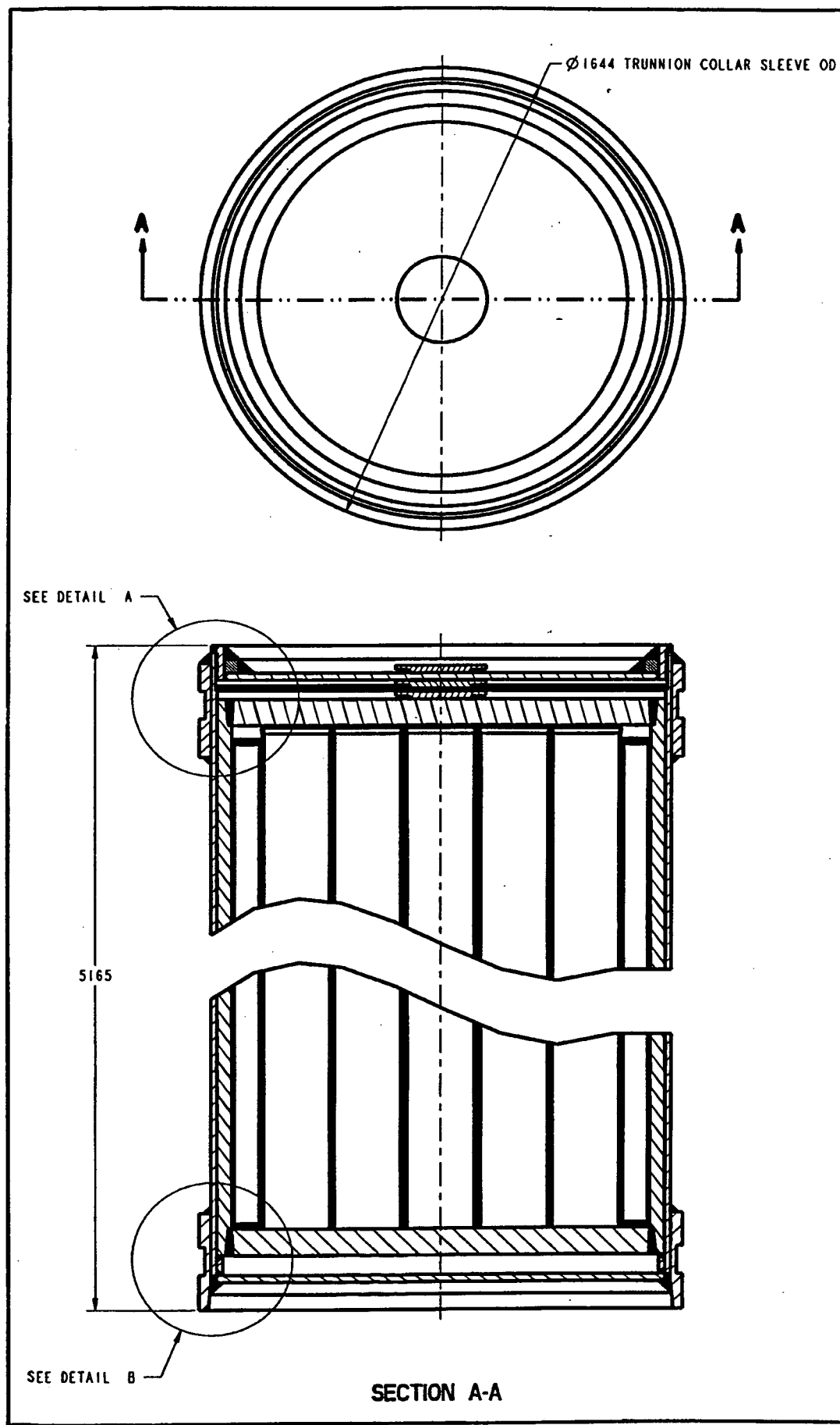
### DETAIL B

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LAS VEGAS, NV: CRWMS M&O. ACC: MOL.19980106.0061

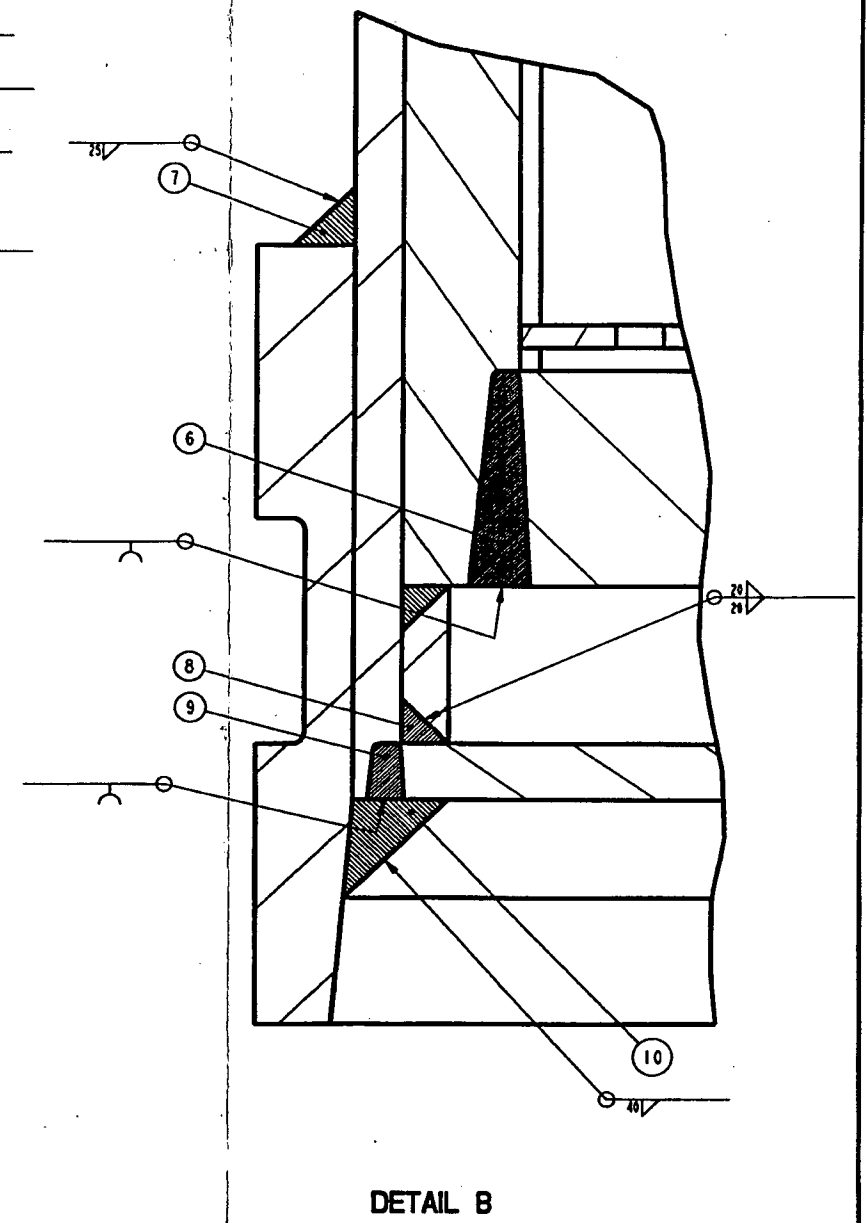
•• REFER TO SK-0191 REV 00 "21-PWR WASTE PACKAGE WELD CONFIGURATION"

02 SMB 01/27/00

SK-0175 REV <del>01</del>	SHEET 2 OF 2
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WELD	MATERIAL	MASS (KG)	QTY ROD
1	SFA-5.14 N06022	14	1
2	SFA-5.14 N06022	35	1
3	SFA-5.14 N06022	96	1
4	SFA-5.14 N06022	3.1	2
5	SFA-5.14 N06022	3.8	1
6	SFA-5.9 S31680	64	2
7	SFA-5.14 N06022	13	2
8	SFA-5.14 N06022	8.2	2
9	SFA-5.14 N06022	14	1
10	SFA-5.14 N06022	37	1
TOTAL ALLOY 22 WELDS		249	-
TOTAL 316 WELDS		128	-



REVISIONS			
REV	DESCRIPTION	OWN BY	DATE
00	ISSUED APPROVED	BR	03/09/00

**"FOR INFORMATION ONLY"**

21-PWR WASTE PACKAGE WELD CONFIGURATION	
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SKETCHED BY:	BRYAN HARKINS
DATE:	03/09/00
FILE:	/home/pro_library/checkout/sketches/21pwr/sk-0191.dwg

*Handwritten notes:* 13 March 00, SMB, 03/13/00, 3/13/00, 2/12/00

UNITS: mm  
DO NOT SCALE FROM SKETCH

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART BASKET\_A-SIDEGUIDE

VOLUME = 3.4753882e+06 MM<sup>3</sup>  
 SURFACE AREA = 7.3523579e+05 MM<sup>2</sup>  
 DENSITY = 7.8500000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 2.7281797e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_BASKET\_A-SIDEGUI coordinate frame:  
 X Y Z 8.5938722e+01 -1.6350460e+01 -5.6700000e+02 MM

INERTIA with respect to \_BASKET\_A-SIDEGUI coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.1715760e+07 1.2976277e+04 1.3293671e+06  
 Iyx Iyy Iyz 1.2976277e+04 1.2045633e+07 -2.5292165e+05  
 Izx Izy Izz 1.3293671e+06 -2.5292165e+05 3.7259956e+05

INERTIA at CENTER OF GRAVITY with respect to \_BASKET\_A-SIDEGUI coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 2.9376691e+06 -2.5358403e+04 0.0000000e+00  
 Iyx Iyy Iyz -2.5358403e+04 3.0733468e+06 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 1.6381739e+05

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 1.6381739e+05 2.9330845e+06 3.0779314e+06

## ROTATION MATRIX from \_BASKET\_A-SIDEGUI orientation to PRINCIPAL AXES:

0.00000 0.98405 -0.17791  
 0.00000 0.17791 0.98405  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_BASKET\_A-SIDEGUI orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 -10.248 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 7.7489615e+01 3.2788821e+02 3.3588683e+02 MM



## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART BASKET\_A-STIFFENER

VOLUME = 9.1313467e+04 MM<sup>3</sup>  
 SURFACE AREA = 2.4001708e+04 MM<sup>2</sup>  
 DENSITY = 7.8500000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 7.1681071e-01 KILOGRAM

CENTER OF GRAVITY with respect to \_BASKET\_A-STIFFEN coordinate frame:  
 X Y Z 7.5253541e+01 -2.8116037e+01 -5.0000000e+00 MM

INERTIA with respect to \_BASKET\_A-STIFFEN coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 8.5943796e+02 1.1971725e+03 2.6971272e+02  
 Iyx Iyy Iyz 1.1971725e+03 5.9707674e+03 -1.0076938e+02  
 Izx Izy Izz 2.6971272e+02 -1.0076938e+02 6.7824180e+03

INERTIA at CENTER OF GRAVITY with respect to \_BASKET\_A-STIFFEN coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 2.7487057e+02 -3.1947807e+02 0.0000000e+00  
 Iyx Iyy Iyz -3.1947807e+02 1.8934797e+03 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 2.1564034e+03

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 2.1409461e+02 1.9542557e+03 2.1564034e+03

## ROTATION MATRIX from \_BASKET\_A-STIFFEN orientation to PRINCIPAL AXES:

0.98238 -0.18688 0.00000  
 0.18688 0.98238 0.00000  
 0.00000 0.00000 1.00000

ROTATION ANGLES from \_BASKET\_A-STIFFEN orientation to PRINCIPAL AXES (degrees):  
 angles about x y z 0.000 0.000 10.771

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 1.7282263e+01 5.2214178e+01 5.4848248e+01 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART BASKET\_B-SIDEGUIDE

VOLUME = 4.5543272e+06 MM<sup>3</sup>  
 SURFACE AREA = 9.4186047e+05 MM<sup>2</sup>  
 DENSITY = 7.8500000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 3.5751469e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_BASKET\_B-SIDEGUI coordinate frame:  
 X Y Z -1.1820000e+02 2.4048996e+01 -5.6700000e+02 MM

INERTIA with respect to \_BASKET\_B-SIDEGUI coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.5372718e+07 1.0162681e+05 -2.3960420e+06  
 Iyx Iyy Iyz 1.0162681e+05 1.6110968e+07 4.8749918e+05  
 Izx Izy Izz -2.3960420e+06 4.8749918e+05 8.3380956e+05

INERTIA at CENTER OF GRAVITY with respect to \_BASKET\_B-SIDEGUI coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 3.8583376e+06 0.0000000e+00 0.0000000e+00  
 Iyx Iyy Iyz 0.0000000e+00 4.1177719e+06 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 3.1364020e+05

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 3.1364020e+05 3.8583376e+06 4.1177719e+06

## ROTATION MATRIX from \_BASKET\_B-SIDEGUI orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_BASKET\_B-SIDEGUI orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 9.3663185e+01 3.2851346e+02 3.3937840e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART BASKET\_B-STIFFENER

VOLUME = 1.8928843e+05 MM<sup>3</sup>  
 SURFACE AREA = 4.4490432e+04 MM<sup>2</sup>  
 DENSITY = 7.8500000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 1.4859142e+00 KILOGRAM

CENTER OF GRAVITY with respect to \_BASKET\_B-STIFFEN coordinate frame:  
 X Y Z 1.0819999e+02 -4.4542218e+01 -5.0000000e+00 MM

INERTIA with respect to \_BASKET\_B-STIFFEN coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 3.9967068e+03 7.1613153e+03 8.0387947e+02  
 Iyx Iyy Iyz 7.1613153e+03 2.3193588e+04 -3.3092956e+02  
 Izx Izy Izz 8.0387947e+02 -3.3092956e+02 2.7091234e+04

INERTIA at CENTER OF GRAVITY with respect to \_BASKET\_B-STIFFEN coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.0114917e+03 3.8048525e-04 0.0000000e+00  
 Iyx Iyy Iyz 3.8048525e-04 5.7604907e+03 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 6.7472171e+03

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 1.0114917e+03 5.7604907e+03 6.7472171e+03

## ROTATION MATRIX from \_BASKET\_B-STIFFEN orientation to PRINCIPAL AXES:

1.00000 0.00000 0.00000  
 0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000

ROTATION ANGLES from \_BASKET\_B-STIFFEN orientation to PRINCIPAL AXES (degrees):  
 angles about x y z 0.000 0.000 0.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 2.6090614e+01 6.2263406e+01 6.7385349e+01 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART BASKET\_C-STIFFENER

VOLUME = 2.9466396e+05 MM<sup>3</sup>  
 SURFACE AREA = 6.7349278e+04 MM<sup>2</sup>  
 DENSITY = 7.8500000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 2.3131121e+00 KILOGRAM

CENTER OF GRAVITY with respect to \_BASKET\_C-STIFFEN coordinate frame:  
 X Y Z 5.7728404e+00 5.7728437e+00 5.0000000e+00 MM

INERTIA with respect to \_BASKET\_C-STIFFEN coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 7.2786355e+03 3.1339778e+03 -6.6766136e+01  
 Iyx Iyy Iyz 3.1339778e+03 7.2786355e+03 -6.6766174e+01  
 Izx Izy Izz -6.6766136e+01 -6.6766174e+01 1.4403064e+04

INERTIA at CENTER OF GRAVITY with respect to \_BASKET\_C-STIFFEN coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 7.1437216e+03 3.2110639e+03 0.0000000e+00  
 Iyx Iyy Iyz 3.2110639e+03 7.1437217e+03 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 1.4248891e+04

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 3.9326577e+03 1.0354786e+04 1.4248891e+04

## ROTATION MATRIX from \_BASKET\_C-STIFFEN orientation to PRINCIPAL AXES:

0.70711 0.70711 0.00000  
 -0.70711 0.70711 0.00000  
 0.00000 0.00000 1.00000

ROTATION ANGLES from \_BASKET\_C-STIFFEN orientation to PRINCIPAL AXES (degrees):  
 angles about x y z 0.000 0.000 -45.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 4.1232981e+01 6.6907101e+01 7.8486000e+01 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART CORNERGUIDE

VOLUME = 5.3364790e+06 MM<sup>3</sup>  
 SURFACE AREA = 1.1033043e+06 MM<sup>2</sup>  
 DENSITY = 7.8500000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 4.1891361e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_CORNERGUIDE coordinate frame:  
 X Y Z 6.3799916e+01 6.3799916e+01 5.6690000e+02 MM

INERTIA with respect to \_CORNERGUIDE coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.8363080e+07 -2.5465443e+04 -1.5151339e+06  
 Iyx Iyy Iyz -2.5465443e+04 1.8363080e+07 -1.5151339e+06  
 Izx Izy Izz -1.5151339e+06 -1.5151339e+06 8.2519577e+05

INERTIA at CENTER OF GRAVITY with respect to \_CORNERGUIDE coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 4.7297026e+06 1.4505038e+05 0.0000000e+00  
 Iyx Iyy Iyz 1.4505038e+05 4.7297026e+06 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 4.8416413e+05

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 4.8416413e+05 4.5846522e+06 4.8747530e+06

## ROTATION MATRIX from \_CORNERGUIDE orientation to PRINCIPAL AXES:

0.00000 0.70711 0.70711  
 0.00000 -0.70711 0.70711  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_CORNERGUIDE orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 45.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 1.0750634e+02 3.3081940e+02 3.4112541e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART A-PLATE

VOLUME = 1.0898874e+07 MM<sup>3</sup>  
 SURFACE AREA = 3.1811360e+06 MM<sup>2</sup>  
 DENSITY = 7.7600000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 8.4575262e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_A-PLATE coordinate frame:  
 X Y Z 6.9800000e+02 5.7174909e+02 3.5000000e+00 MM

INERTIA with respect to \_A-PLATE coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 3.6710214e+07 -3.3752369e+07 -2.0661737e+05  
 Iyx Iyy Iyz -3.3752369e+07 5.5082751e+07 -1.6924540e+05  
 Izx Izy Izz -2.0661737e+05 -1.6924540e+05 9.1790202e+07

INERTIA at CENTER OF GRAVITY with respect to \_A-PLATE coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 9.0617767e+06 0.0000000e+00 0.0000000e+00  
 Iyx Iyy Iyz 0.0000000e+00 1.3876309e+07 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 2.2937395e+07

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 9.0617767e+06 1.3876309e+07 2.2937395e+07

## ROTATION MATRIX from \_A-PLATE orientation to PRINCIPAL AXES:

1.00000 0.00000 0.00000  
 0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000

ROTATION ANGLES from \_A-PLATE orientation to PRINCIPAL AXES (degrees):  
 angles about x y z 0.000 0.000 0.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 3.2732939e+02 4.0505622e+02 5.2077529e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART B-PLATE

VOLUME = 1.0898874e+07 MM<sup>3</sup>  
 SURFACE AREA = 3.1811360e+06 MM<sup>2</sup>  
 DENSITY = 7.7600000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 8.4575262e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_B-PLATE coordinate frame:  
 X Y Z 6.9800000e+02 -3.5000000e+00 5.6803241e+02 MM

INERTIA with respect to \_B-PLATE coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 3.6353754e+07 2.0661737e+05 -3.3532960e+07  
 Iyx Iyy Iyz 2.0661737e+05 9.1433742e+07 1.6814522e+05  
 Izx Izy Izz -3.3532960e+07 1.6814522e+05 5.5082751e+07

INERTIA at CENTER OF GRAVITY with respect to \_B-PLATE coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 9.0635940e+06 0.0000000e+00 0.0000000e+00  
 Iyx Iyy Iyz 0.0000000e+00 2.2939212e+07 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 1.3876309e+07

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 9.0635940e+06 1.3876309e+07 2.2939212e+07

## ROTATION MATRIX from \_B-PLATE orientation to PRINCIPAL AXES:

1.00000 0.00000 0.00000  
 0.00000 0.00000 -1.00000  
 0.00000 1.00000 0.00000

ROTATION ANGLES from \_B-PLATE orientation to PRINCIPAL AXES (degrees):  
 angles about x y z 90.000 0.000 0.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 3.2736221e+02 4.0505622e+02 5.2079592e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART C-PLATE

VOLUME = 5.7090096e+06 MM<sup>3</sup>  
 SURFACE AREA = 1.6731624e+06 MM<sup>2</sup>  
 DENSITY = 7.7600000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 4.4301914e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_C-PLATE coordinate frame:  
 X Y Z 3.6660584e+02 -3.5000000e+00 5.6148137e+02 MM

INERTIA with respect to \_C-PLATE coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.8713581e+07 5.6844692e+04 -9.1192849e+06  
 Iyx Iyy Iyz 5.6844692e+04 2.6677026e+07 8.7061448e+04  
 Izx Izy Izz -9.1192849e+06 8.7061448e+04 7.9648921e+06

INERTIA at CENTER OF GRAVITY with respect to \_C-PLATE coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 4.7463577e+06 0.0000000e+00 -7.4773541e+01  
 Iyx Iyy Iyz 0.0000000e+00 6.7561750e+06 0.0000000e+00  
 Izx Izy Izz -7.4773541e+01 0.0000000e+00 2.0101791e+06

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 2.0101791e+06 4.7463577e+06 6.7561750e+06

## ROTATION MATRIX from \_C-PLATE orientation to PRINCIPAL AXES:

0.00003 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 -0.00003 0.00000

ROTATION ANGLES from \_C-PLATE orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -89.998

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 2.1301301e+02 3.2731732e+02 3.9051633e+02 MM



## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART D-PLATE

VOLUME = 7.7598600e+06 MM<sup>3</sup>  
 SURFACE AREA = 3.1518440e+06 MM<sup>2</sup>  
 DENSITY = 2.7000000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 2.0951622e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_D-PLATE coordinate frame:

X Y Z 6.9700000e+02 5.7074763e+02 2.5000000e+00 MM

INERTIA with respect to \_D-PLATE coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 9.0620790e+06 -8.3347877e+06 -3.6508201e+04  
 Iyx Iyy Iyz -8.3347877e+06 1.3606264e+07 -2.9895221e+04  
 Izx Izy Izz -3.6508201e+04 -2.9895221e+04 2.2667994e+07

INERTIA at CENTER OF GRAVITY with respect to \_D-PLATE coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 2.2368973e+06 0.0000000e+00 0.0000000e+00  
 Iyx Iyy Iyz 0.0000000e+00 3.4276470e+06 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 5.6644570e+06

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 2.2368973e+06 3.4276470e+06 5.6644570e+06

ROTATION MATRIX from \_D-PLATE orientation to PRINCIPAL AXES:

1.00000 0.00000 0.00000  
 0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000

ROTATION ANGLES from \_D-PLATE orientation to PRINCIPAL AXES (degrees):

angles about x y z 0.000 0.000 0.000

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 3.2674895e+02 4.0447271e+02 5.1996046e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART E-PLATE

VOLUME = 7.7598600e+06 MM<sup>3</sup>  
 SURFACE AREA = 3.1518440e+06 MM<sup>2</sup>  
 DENSITY = 2.7000000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 2.0951622e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_E-PLATE coordinate frame:  
 X Y Z 6.9700000e+02 -2.5000000e+00 5.6703209e+02 MM

~~INERTIA with respect to \_E-PLATE coordinate frame: (KILOGRAM \* MM<sup>2</sup>)~~

## INERTIA TENSOR:

Ixx Ixy Ixz	8.9739568e+06	3.6508201e+04	-8.2805287e+06
Iyx Iyy Iyz	3.6508201e+04	2.2579872e+07	2.9700605e+04
Izx Izy Izz	-8.2805287e+06	2.9700605e+04	1.3606264e+07

INERTIA at CENTER OF GRAVITY with respect to \_E-PLATE coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz	2.2373473e+06	0.0000000e+00	0.0000000e+00
Iyx Iyy Iyz	0.0000000e+00	5.6649070e+06	0.0000000e+00
Izx Izy Izz	0.0000000e+00	0.0000000e+00	3.4276470e+06

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3	2.2373473e+06	3.4276470e+06	5.6649070e+06
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## ROTATION MATRIX from \_E-PLATE orientation to PRINCIPAL AXES:

1.00000	0.00000	0.00000
0.00000	0.00000	-1.00000
0.00000	1.00000	0.00000

ROTATION ANGLES from \_E-PLATE orientation to PRINCIPAL AXES (degrees):  
 angles about x y z 90.000 0.000 0.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3	3.2678181e+02	4.0447271e+02	5.1998111e+02 MM
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## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART TUBE

VOLUME = 2.0879659e+07 MM<sup>3</sup>  
 SURFACE AREA = 8.3616621e+06 MM<sup>2</sup>  
 DENSITY = 7.8500000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 1.6390532e+02 KILOGRAM

## CENTER OF GRAVITY with respect to \_TUBE coordinate frame:

X Y Z 1.1320000e+02 -1.1320000e+02 2.2876201e+03 MM

INERTIA with respect to \_TUBE coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.1472196e+09 2.1003222e+06 -4.2444692e+07  
 Iyx Iyy Iyz 2.1003222e+06 1.1472196e+09 4.2444691e+07  
 Izx Izy Izz -4.2444692e+07 4.2444691e+07 7.1055829e+06

INERTIA at CENTER OF GRAVITY with respect to \_TUBE coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 2.8736906e+08 0.0000000e+00 0.0000000e+00  
 Iyx Iyy Iyz 0.0000000e+00 2.8736906e+08 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 2.9049385e+06

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 2.9049385e+06 2.8736906e+08 2.8736906e+08

## ROTATION MATRIX from \_TUBE orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_TUBE orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 1.3312878e+02 1.3241082e+03 1.3241082e+03 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART INNERBARRIER

VOLUME = 1.0913649e+09 MM<sup>3</sup>  
 SURFACE AREA = 4.4610318e+07 MM<sup>2</sup>  
 DENSITY = 7.9800000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 8.7090915e+03 KILOGRAM

CENTER OF GRAVITY with respect to \_INNERBARRIER coordinate frame:  
 X Y Z 0.0000000e+00 0.0000000e+00 2.3875000e+03 MM

INERTIA with respect to \_INNERBARRIER coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 6.8151962e+10 4.6745531e+04 0.0000000e+00  
 Iyx Iyy Iyz 4.6745531e+04 6.8151964e+10 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 4.7387384e+09

INERTIA at CENTER OF GRAVITY with respect to \_INNERBARRIER coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.8508779e+10 4.6745531e+04 0.0000000e+00  
 Iyx Iyy Iyz 4.6745531e+04 1.8508781e+10 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 4.7387384e+09

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 4.7387384e+09 1.8508733e+10 1.8508827e+10

## ROTATION MATRIX from \_INNERBARRIER orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_INNERBARRIER orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 7.3764082e+02 1.4578133e+03 1.4578170e+03 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART INNERLID

VOLUME = 1.5037864e+08 MM<sup>3</sup>  
 SURFACE AREA = 3.6104442e+06 MM<sup>2</sup>  
 DENSITY = 7.9800000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 1.2000215e+03 KILOGRAM

## CENTER OF GRAVITY with respect to \_INNERLID coordinate frame:

X Y Z 0.0000000e+00 0.0000000e+00 4.7386565e+01 MM

INERTIA with respect to \_INNERLID coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.5476137e+08 4.5134424e+02 0.0000000e+00  
 Iyx Iyy Iyz 4.5134424e+02 1.5476167e+08 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 3.0232859e+08

INERTIA at CENTER OF GRAVITY with respect to \_INNERLID coordinate frame:  
(KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.5206674e+08 4.5134424e+02 0.0000000e+00  
 Iyx Iyy Iyz 4.5134424e+02 1.5206704e+08 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 3.0232859e+08

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 1.5206641e+08 1.5206736e+08 3.0232859e+08

## ROTATION MATRIX from \_INNERLID orientation to PRINCIPAL AXES:

1.00000 0.00000 0.00000  
 0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000

## ROTATION ANGLES from \_INNERLID orientation to PRINCIPAL AXES (degrees):

angles about x y z 0.000 0.000 0.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 3.5597716e+02 3.5597827e+02 5.0193224e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART INNER-LID-LIFT-FEATURE-SS

VOLUME = 1.5039006e+06 MM<sup>3</sup>  
 SURFACE AREA = 1.6529893e+05 MM<sup>2</sup>  
 DENSITY = 7.9800000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 1.2001127e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_INNER-LID-LIFT-F coordinate frame:  
 X Y Z 0.0000000e+00 0.0000000e+00 3.8603637e+00 MM

INERTIA with respect to \_INNER-LID-LIFT-F coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 6.0407335e+04 -8.7984862e-02 0.0000000e+00  
 Iyx Iyy Iyz -8.7984862e-02 6.0407177e+04 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 1.1919968e+05

INERTIA at CENTER OF GRAVITY with respect to \_INNER-LID-LIFT-F coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 6.0228489e+04 -8.7984862e-02 0.0000000e+00  
 Iyx Iyy Iyz -8.7984862e-02 6.0228332e+04 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 1.1919968e+05

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 6.0228292e+04 6.0228528e+04 1.1919968e+05

## ROTATION MATRIX from \_INNER-LID-LIFT-F orientation to PRINCIPAL AXES:

1.00000 0.00000 0.00000  
 0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000

ROTATION ANGLES from \_INNER-LID-LIFT-F orientation to PRINCIPAL AXES (degrees):  
 angles about x y z 0.000 0.000 0.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 7.0841746e+01 7.0841885e+01 9.9661297e+01 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART WP-OUTERSHELL\_NEW\_

VOLUME = 4.8255885e+08 MM<sup>3</sup>  
 SURFACE AREA = 4.9304910e+07 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 4.1934364e+03 KILOGRAM

CENTER OF GRAVITY with respect to \_WP-OUTERSHELL\_NE coordinate frame:  
 X Y Z -1.0897083e-02 -2.5050051e+03 0.0000000e+00 MM

INERTIA with respect to \_WP-OUTERSHELL\_NE coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 3.6247028e+10 -2.0830700e+05 0.0000000e+00  
 Iyx Iyy Iyz -2.0830700e+05 2.5027833e+09 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 3.6247023e+10

INERTIA at CENTER OF GRAVITY with respect to \_WP-OUTERSHELL\_NE coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 9.9330021e+09 -9.3837727e+04 0.0000000e+00  
 Iyx Iyy Iyz -9.3837727e+04 2.5027833e+09 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 9.9329973e+09

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 2.5027833e+09 9.9329970e+09 9.9330024e+09

## ROTATION MATRIX from \_WP-OUTERSHELL\_NE orientation to PRINCIPAL AXES:

0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000  
 0.00000 1.00000 0.00000

ROTATION ANGLES from \_WP-OUTERSHELL\_NE orientation to PRINCIPAL AXES (degrees):  
 angles about x y z 0.000 90.000 90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 7.7254999e+02 1.5390585e+03 1.5390589e+03 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART WP-EXTENDED-LID\_NEW\_

VOLUME = 1.5192659e+07 MM<sup>3</sup>  
 SURFACE AREA = 1.4734575e+06 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 1.3202420e+02 KILOGRAM

CENTER OF GRAVITY with respect to WP-EXTENDED-LID\_ coordinate frame:  
 X Y Z 0.0000000e+00 -6.3942382e+01 0.0000000e+00 MM

INERTIA with respect to WP-EXTENDED-LID\_ coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 3.7999228e+07 0.0000000e+00 2.0920291e+01  
 Iyx Iyy Iyz 0.0000000e+00 7.4566604e+07 0.0000000e+00  
 Izx Izy Izz 2.0920291e+01 0.0000000e+00 3.7999214e+07

INERTIA at CENTER OF GRAVITY with respect to WP-EXTENDED-LID\_ coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 3.7459430e+07 0.0000000e+00 2.0920291e+01  
 Iyx Iyy Iyz 0.0000000e+00 7.4566604e+07 0.0000000e+00  
 Izx Izy Izz 2.0920291e+01 0.0000000e+00 3.7459416e+07

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 3.7459401e+07 3.7459445e+07 7.4566604e+07

## ROTATION MATRIX from WP-EXTENDED-LID\_ orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from WP-EXTENDED-LID\_ orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 5.3266435e+02 5.3266467e+02 7.5152841e+02 MM



## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART EXTENDED-LID-BASE\_NEW\_

VOLUME = 4.2113292e+07 MM<sup>3</sup>  
 SURFACE AREA = 3.4743812e+06 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 3.6596450e+02 KILOGRAM

CENTER OF GRAVITY with respect to \_EXTENDED-LID-BAS coordinate frame:  
 X Y Z 0.0000000e+00 0.0000000e+00 1.2500000e+01 MM

INERTIA with respect to \_EXTENDED-LID-BAS coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 4.9138617e+07 -1.6093784e+02 0.0000000e+00  
 Iyx Iyy Iyz -1.6093784e+02 4.9138721e+07 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 9.8125178e+07

INERTIA at CENTER OF GRAVITY with respect to \_EXTENDED-LID-BAS coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 4.9081435e+07 -1.6093784e+02 0.0000000e+00  
 Iyx Iyy Iyz -1.6093784e+02 4.9081539e+07 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 9.8125178e+07

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 4.9081318e+07 4.9081656e+07 9.8125178e+07

## ROTATION MATRIX from \_EXTENDED-LID-BAS orientation to PRINCIPAL AXES:

1.00000 0.00000 0.00000  
 0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000

ROTATION ANGLES from \_EXTENDED-LID-BAS orientation to PRINCIPAL AXES (degrees):  
 angles about x y z 0.000 0.000 0.000

## RADIOI OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 3.6621711e+02 3.6621837e+02 5.1781037e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART OUTER-LID-LIFT-FEATURE

VOLUME = 1.5039006e+06 MM<sup>3</sup>  
 SURFACE AREA = 1.6529893e+05 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 1.3068897e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_OUTER-LID-LIFT-F coordinate frame:  
 X Y Z 0.0000000e+00 0.0000000e+00 3.8603637e+00 MM

INERTIA with respect to \_OUTER-LID-LIFT-F coordinate frame: ---(KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 6.5781922e+04 -9.5813089e-02 0.0000000e+00  
 Iyx Iyy Iyz -9.5813089e-02 6.5781751e+04 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 1.2980517e+05

INERTIA at CENTER OF GRAVITY with respect to \_OUTER-LID-LIFT-F coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 6.5587164e+04 -9.5813089e-02 0.0000000e+00  
 Iyx Iyy Iyz -9.5813089e-02 6.5586993e+04 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 1.2980517e+05

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 6.5586950e+04 6.5587207e+04 1.2980517e+05

## ROTATION MATRIX from \_OUTER-LID-LIFT-F orientation to PRINCIPAL AXES:

1.00000 0.00000 0.00000  
 0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000

ROTATION ANGLES from \_OUTER-LID-LIFT-F orientation to PRINCIPAL AXES (degrees):  
 angles about x y z 0.000 0.000 0.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 7.0841746e+01 7.0841885e+01 9.9661297e+01 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART EXTENDED-LID-WELD-BLOCK

VOLUME = 1.1207632e+07 MM<sup>3</sup>  
 SURFACE AREA = 8.9661054e+05 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 9.7394320e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_EXTENDED-LID-WEL coordinate frame:  
 X Y Z 0.0000000e+00 -2.5000000e+01 0.0000000e+00 MM

INERTIA with respect to \_EXTENDED-LID-WEL coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 2.4902457e+07 0.0000000e+00 -2.4219334e+00  
 Iyx Iyy Iyz 0.0000000e+00 4.9642591e+07 0.0000000e+00  
 Izx Izy Izz -2.4219334e+00 0.0000000e+00 2.4902458e+07

INERTIA at CENTER OF GRAVITY with respect to \_EXTENDED-LID-WEL coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 2.4841585e+07 0.0000000e+00 -2.4219334e+00  
 Iyx Iyy Iyz 0.0000000e+00 4.9642591e+07 0.0000000e+00  
 Izx Izy Izz -2.4219334e+00 0.0000000e+00 2.4841587e+07

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 2.4841584e+07 2.4841589e+07 4.9642591e+07

## ROTATION MATRIX from \_EXTENDED-LID-WEL orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_EXTENDED-LID-WEL orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 5.0503657e+02 5.0503662e+02 7.1393785e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART FLAT-CLOSURE-LID

VOLUME = 1.8313357e+07 MM<sup>3</sup>  
 SURFACE AREA = 3.7106435e+06 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 1.5914307e+02 KILOGRAM

CENTER OF GRAVITY with respect to \_FLAT-CLOSURE-LID coordinate frame:  
 X Y Z 0.0000000e+00 0.0000000e+00 5.0000000e+00 MM

INERTIA with respect to \_FLAT-CLOSURE-LID coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 2.3197736e+07 -7.5438672e+01 0.0000000e+00  
 Iyx Iyy Iyz -7.5438672e+01 2.3197687e+07 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 4.6384814e+07

INERTIA at CENTER OF GRAVITY with respect to \_FLAT-CLOSURE-LID coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 2.3193758e+07 -7.5438672e+01 0.0000000e+00  
 Iyx Iyy Iyz -7.5438672e+01 2.3193709e+07 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 4.6384814e+07

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 2.3193654e+07 2.3193812e+07 4.6384814e+07

## ROTATION MATRIX from \_FLAT-CLOSURE-LID orientation to PRINCIPAL AXES:

1.00000 0.00000 0.00000  
 0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000

ROTATION ANGLES from \_FLAT-CLOSURE-LID orientation to PRINCIPAL AXES (degrees):  
 angles about x y z 0.000 0.000 0.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 3.8176026e+02 3.8176157e+02 5.3987603e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART FLAT-OUTER-LID-BOTTOM

VOLUME = 4.5569749e+07 MM<sup>3</sup>  
 SURFACE AREA = 3.7866036e+06 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 3.9600111e+02 KILOGRAM

CENTER OF GRAVITY with respect to \_FLAT-OUTER-LID-B coordinate frame:  
 X Y Z 0.0000000e+00 0.0000000e+00 1.2509299e+01 MM

INERTIA with respect to \_FLAT-OUTER-LID-B coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 5.7523811e+07 -2.0269741e+02 0.0000000e+00  
 Iyx Iyy Iyz -2.0269741e+02 5.7523943e+07 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 1.1488256e+08

INERTIA at CENTER OF GRAVITY with respect to \_FLAT-OUTER-LID-B coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 5.7461844e+07 -2.0269741e+02 0.0000000e+00  
 Iyx Iyy Iyz -2.0269741e+02 5.7461975e+07 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 1.1488256e+08

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 5.7461696e+07 5.7462123e+07 1.1488256e+08

## ROTATION MATRIX from \_FLAT-OUTER-LID-B orientation to PRINCIPAL AXES:

1.00000 0.00000 0.00000  
 0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000

ROTATION ANGLES from \_FLAT-OUTER-LID-B orientation to PRINCIPAL AXES (degrees):  
 angles about x y z 0.000 0.000 0.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 3.8092635e+02 3.8092776e+02 5.3861549e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART TRUNNION\_COLLARSLEEVE\_NEW\_

VOLUME = 5.8382151e+07 MM<sup>3</sup>  
 SURFACE AREA = 3.9996364e+06 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 5.0734089e+02 KILOGRAM

CENTER OF GRAVITY with respect to \_TRUNNION\_COLLARS coordinate frame:  
 X Y Z 0.0000000e+00 -1.6652297e+02 0.0000000e+00 MM

INERTIA with respect to \_TRUNNION\_COLLARS coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz	1.8225281e+08	0.0000000e+00	0.0000000e+00
Iyx Iyy Iyz	0.0000000e+00	3.2512284e+08	0.0000000e+00
Izx Izy Izz	0.0000000e+00	0.0000000e+00	1.8225281e+08

INERTIA at CENTER OF GRAVITY with respect to \_TRUNNION\_COLLARS coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz	1.6818429e+08	0.0000000e+00	0.0000000e+00
Iyx Iyy Iyz	0.0000000e+00	3.2512284e+08	0.0000000e+00
Izx Izy Izz	0.0000000e+00	0.0000000e+00	1.6818430e+08

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3	1.6818424e+08	1.6818436e+08	3.2512284e+08
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## ROTATION MATRIX from \_TRUNNION\_COLLARS orientation to PRINCIPAL AXES:

0.00000	1.00000	0.00000
0.00000	0.00000	1.00000
1.00000	0.00000	0.00000

ROTATION ANGLES from \_TRUNNION\_COLLARS orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3	5.7576162e+02	5.7576183e+02	8.0052298e+02 MM
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## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART LOWER-TRUNNION-COLLAR-SLEEVE

VOLUME = 5.7232595e+07 MM<sup>3</sup>  
 SURFACE AREA = 4.0114363e+06 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 4.9735125e+02 KILOGRAM

CENTER OF GRAVITY with respect to \_LOWER-TRUNNION-C coordinate frame:  
 X Y Z 0.0000000e+00 -1.7730367e+02 0.0000000e+00 MM

INERTIA with respect to \_LOWER-TRUNNION-C coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.8077498e+08 0.0000000e+00 -1.4799873e+02  
 Iyx Iyy Iyz 0.0000000e+00 3.1920900e+08 0.0000000e+00  
 Izx Izy Izz -1.4799873e+02 0.0000000e+00 1.8077497e+08

INERTIA at CENTER OF GRAVITY with respect to \_LOWER-TRUNNION-C coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.6513996e+08 0.0000000e+00 -1.4799873e+02  
 Iyx Iyy Iyz 0.0000000e+00 3.1920900e+08 0.0000000e+00  
 Izx Izy Izz -1.4799873e+02 0.0000000e+00 1.6513994e+08

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 1.6513980e+08 1.6514010e+08 3.1920900e+08

## ROTATION MATRIX from \_LOWER-TRUNNION-C orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_LOWER-TRUNNION-C orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 5.7622789e+02 5.7622840e+02 8.0113546e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART IB-SUPPORTRING

VOLUME = 4.7165778e+06 MM<sup>3</sup>  
 SURFACE AREA = 7.3726610e+05 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 4.0987061e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_IB-SUPPORTRING coordinate frame:

X Y Z 0.0000000e+00 -3.5000000e+01 0.0000000e+00 MM

INERTIA with respect to \_IB-SUPPORTRING coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.1610135e+07 0.0000000e+00 -1.4866794e+01  
 Iyx Iyy Iyz 0.0000000e+00 2.3100110e+07 0.0000000e+00  
 Izx Izy Izz -1.4866794e+01 0.0000000e+00 1.1610145e+07

INERTIA at CENTER OF GRAVITY with respect to \_IB-SUPPORTRING coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.1559926e+07 0.0000000e+00 -1.4866794e+01  
 Iyx Iyy Iyz 0.0000000e+00 2.3100110e+07 0.0000000e+00  
 Izx Izy Izz -1.4866794e+01 0.0000000e+00 1.1559936e+07

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 1.1559915e+07 1.1559946e+07 2.3100110e+07

ROTATION MATRIX from \_IB-SUPPORTRING orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_IB-SUPPORTRING orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 5.3107265e+02 5.3107337e+02 7.5072976e+02 MM



## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE ASSEMBLY 21-PWR-TOP-ASSEMBLY

VOLUME = 3.2956933e+09 MM<sup>3</sup>  
 SURFACE AREA = 4.9665396e+08 MM<sup>2</sup>  
 AVERAGE DENSITY = 7.8997900e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 2.6035285e+04 KILOGRAM

## CENTER OF GRAVITY with respect to ACS4 coordinate frame:

X Y Z 8.2200000e+02 -2.6232408e+03 0.0000000e+00 MM

INERTIA with respect to ACS4 coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 2.5216931e+11 5.6139987e+10 0.0000000e+00  
 Iyx Iyy Iyz 5.6139987e+10 2.8819761e+10 -2.1288726e+05  
 Izx Izy Izz 0.0000000e+00 -2.1288726e+05 2.6976093e+11

INERTIA at CENTER OF GRAVITY with respect to ACS4 coordinate frame:  
(KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 7.3010297e+10 0.0000000e+00 0.0000000e+00  
 Iyx Iyy Iyz 0.0000000e+00 1.1228135e+10 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 7.3010299e+10

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 1.1228135e+10 7.3010252e+10 7.3010344e+10

## ROTATION MATRIX from ACS4 orientation to PRINCIPAL AXES:

0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000  
 0.00000 1.00000 0.00000

## ROTATION ANGLES from ACS4 orientation to PRINCIPAL AXES (degrees):

angles about x y z 0.000 90.000 90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 6.5670852e+02 1.6745987e+03 1.6745998e+03 MM

## Mass Properties of 21-PWR Waste Package

MASS PROPERTIES OF COMPONENTS OF THE ASSEMBLY  
(in assembly units and the ACS4 coordinate frame)

	DENSITY	MASS	MATERIAL C.G.: X	Y	Z
WP-OUTERSHELL_NEW_			UNKNOWN		
	8.69000e-06	4.19344e+03	8.22000e+02	-2.60501e+03	-1.08971e-02
TOP_EXTENDED-OUTERLID			UNKNOWN		
	8.69000e-06	7.10304e+02	8.22000e+02	-5.07512e+03	8.95037e-13
WP_EXTENDED_LID-CLOSUREWELD_			UNKNOWN		
	8.69000e-06	1.38243e+01	8.22000e+02	-5.15325e+03	7.69251e-13
FLAT-CLOSURE-LID-ASSEMBLY			UNKNOWN		
	8.69000e-06	1.75970e+02	8.22000e+02	-5.00665e+03	2.38240e-13
FLAT-OUTER-LID-BOTTOM			UNKNOWN		
	8.69000e-06	3.96001e+02	8.22000e+02	-1.12509e+02	1.48383e-13
FLATLID-BOTTOM-WELD			UNKNOWN		
	8.69000e-06	1.37261e+01	8.22000e+02	-1.11755e+02	1.09263e-12
IB-ASSEMBLY			UNKNOWN		
	7.66016e-06	1.93713e+04	8.22000e+02	-2.57718e+03	-5.09980e-07
TRUNNION_COLLARSLEEVE_NEW_			UNKNOWN		
	8.69000e-06	5.07341e+02	8.22000e+02	-4.92652e+03	1.33248e-12
RINGWELD_NEW_			UNKNOWN		
	8.69000e-06	3.47407e+01	8.22000e+02	-5.11328e+03	-1.32698e-13
SMALL-RINGWELD			UNKNOWN		
	8.69000e-06	1.34853e+01	8.22000e+02	-4.75169e+03	-2.24931e-13
LOWER-TRUNNION-COLLAR-SLEEVE			UNKNOWN		
	8.69000e-06	4.97351e+02	8.22000e+02	-1.77304e+02	2.22345e-12
SMALL-RINGWELD			UNKNOWN		
	8.69000e-06	1.34853e+01	8.22000e+02	-3.53311e+02	5.26929e-13
TRUNNION-SKIRT-WELD			UNKNOWN		
	8.69000e-06	3.68562e+01	8.22000e+02	-8.53129e+01	2.35974e-13
IB-SUPPORTRING-ASM			UNKNOWN		
	8.69000e-06	5.74838e+01	8.22000e+02	-1.60000e+02	2.95169e-13

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART WP\_EXTENDED\_LID-CLOSUREWELD\_

VOLUME = 1.5908342e+06 MM<sup>3</sup>  
 SURFACE AREA = 3.6203709e+05 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 1.3824349e+01 KILOGRAM

CENTER OF GRAVITY with respect to WP\_EXTENDED\_LID- coordinate frame:  
 X Y Z 0.0000000e+00 1.3245241e+01 0.0000000e+00 MM

INERTIA with respect to WP\_EXTENDED\_LID- coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 4.1419866e+06 0.0000000e+00 3.1790704e-01  
 Iyx Iyy Iyz 0.0000000e+00 8.2777223e+06 0.0000000e+00  
 Izx Izy Izz 3.1790704e-01 0.0000000e+00 4.1419868e+06

INERTIA at CENTER OF GRAVITY with respect to WP\_EXTENDED\_LID- coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 4.1395613e+06 0.0000000e+00 3.1790704e-01  
 Iyx Iyy Iyz 0.0000000e+00 8.2777223e+06 0.0000000e+00  
 Izx Izy Izz 3.1790704e-01 0.0000000e+00 4.1395615e+06

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 4.1395610e+06 4.1395617e+06 8.2777223e+06

## ROTATION MATRIX from WP\_EXTENDED\_LID- orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from WP\_EXTENDED\_LID- orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 5.4721097e+02 5.4721102e+02 7.7380776e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART RINGWELD\_NEW\_

VOLUME = 3.9977814e+06 MM<sup>3</sup>  
 SURFACE AREA = 6.8315799e+05 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 3.4740720e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_RINGWELD\_NEW\_ coordinate frame:  
 X Y Z 0.0000000e+00 1.3277452e+01 0.0000000e+00 MM

INERTIA with respect to \_RINGWELD\_NEW\_ coordinate frame: ---(KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.1001554e+07 0.0000000e+00 1.0657224e+00  
 Iyx Iyy Iyz 0.0000000e+00 2.1984705e+07 0.0000000e+00  
 Izx Izy Izz 1.0657224e+00 0.0000000e+00 1.1001555e+07

INERTIA at CENTER OF GRAVITY with respect to \_RINGWELD\_NEW\_ coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.0995430e+07 0.0000000e+00 1.0657224e+00  
 Iyx Iyy Iyz 0.0000000e+00 2.1984705e+07 0.0000000e+00  
 Izx Izy Izz 1.0657224e+00 0.0000000e+00 1.0995430e+07

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 1.0995429e+07 1.0995431e+07 2.1984705e+07

## ROTATION MATRIX from \_RINGWELD\_NEW\_ orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_RINGWELD\_NEW\_ orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 5.6258310e+02 5.6258316e+02 7.9550133e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART WP-LID-FILLET\_NEW\_

VOLUME = 1.0999725e+07 MM<sup>3</sup>  
 SURFACE AREA = 1.5707569e+06 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 9.5587609e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_WP-LID-FILLET\_NE coordinate frame:  
 X Y Z 0.0000000e+00 -4.2461607e+01 0.0000000e+00 MM

INERTIA with respect to \_WP-LID-FILLET\_NE coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 2.3543816e+07 0.0000000e+00 -2.0438821e+01  
 Iyx Iyy Iyz 0.0000000e+00 4.6596129e+07 0.0000000e+00  
 Izx Izy Izz -2.0438821e+01 0.0000000e+00 2.3543839e+07

INERTIA at CENTER OF GRAVITY with respect to \_WP-LID-FILLET\_NE coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 2.3371473e+07 0.0000000e+00 -2.0438821e+01  
 Iyx Iyy Iyz 0.0000000e+00 4.6596129e+07 0.0000000e+00  
 Izx Izy Izz -2.0438821e+01 0.0000000e+00 2.3371496e+07

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 2.3371461e+07 2.3371508e+07 4.6596129e+07

## ROTATION MATRIX from \_WP-LID-FILLET\_NE orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_WP-LID-FILLET\_NE orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 4.9447248e+02 4.9447298e+02 6.9819080e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART OB-EXTENDED-LID-BASE-WELD

VOLUME = 3.6046503e+05 MM<sup>3</sup>  
 SURFACE AREA = 1.9684496e+05 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 3.1324411e+00 KILOGRAM

CENTER OF GRAVITY with respect to \_OB-EXTENDED-LID- coordinate frame:  
 X Y Z 0.0000000e+00 4.1725772e+00 0.0000000e+00 MM

INERTIA with respect to \_OB-EXTENDED-LID- coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz	8.4469982e+05	0.0000000e+00	3.9308675e-03
Iyx Iyy Iyz	0.0000000e+00	1.6892361e+06	0.0000000e+00
Izx Izy Izz	3.9308675e-03	0.0000000e+00	8.4469982e+05

INERTIA at CENTER OF GRAVITY with respect to \_OB-EXTENDED-LID- coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz	8.4464528e+05	0.0000000e+00	3.9308675e-03
Iyx Iyy Iyz	0.0000000e+00	1.6892361e+06	0.0000000e+00
Izx Izy Izz	3.9308675e-03	0.0000000e+00	8.4464528e+05

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3	8.4464528e+05	8.4464528e+05	1.6892361e+06
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## ROTATION MATRIX from \_OB-EXTENDED-LID- orientation to PRINCIPAL AXES:

0.00000	1.00000	0.00000
0.00000	0.00000	1.00000
1.00000	0.00000	0.00000

ROTATION ANGLES from \_OB-EXTENDED-LID- orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3	5.1927298e+02	5.1927298e+02	7.3435105e+02 MM
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## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART FLATLID-CLOSUREWELD

VOLUME = 4.3246117e+05 MM<sup>3</sup>  
 SURFACE AREA = 2.6008227e+05 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 3.7580876e+00 KILOGRAM

CENTER OF GRAVITY with respect to \_FLATLID-CLOSUREW coordinate frame:

X Y Z 0.0000000e+00 -3.7193985e-01 0.0000000e+00 MM

- INERTIA with respect to \_FLATLID-CLOSUREW coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.0990852e+06 0.0000000e+00 2.2123126e-01  
 Iyx Iyy Iyz 0.0000000e+00 2.1979892e+06 0.0000000e+00  
 Izx Izy Izz 2.2123126e-01 0.0000000e+00 1.0990852e+06

INERTIA at CENTER OF GRAVITY with respect to \_FLATLID-CLOSUREW coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.0990846e+06 0.0000000e+00 2.2123126e-01  
 Iyx Iyy Iyz 0.0000000e+00 2.1979892e+06 0.0000000e+00  
 Izx Izy Izz 2.2123126e-01 0.0000000e+00 1.0990846e+06

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 1.0990844e+06 1.0990849e+06 2.1979892e+06

## ROTATION MATRIX from \_FLATLID-CLOSUREW orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_FLATLID-CLOSUREW orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 5.4079426e+02 5.4079437e+02 7.6476733e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART INNERLID-WELD

VOLUME = 8.0277469e+06 MM<sup>3</sup>  
 SURFACE AREA = 1.0212646e+06 MM<sup>2</sup>  
 DENSITY = 7.9800000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 6.4061421e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_INNERLID-WELD coordinate frame:

X Y Z 0.0000000e+00 5.3946946e+01 0.0000000e+00 MM

INERTIA with respect to \_INNERLID-WELD coordinate frame: --(KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.6809783e+07 0.0000000e+00 0.0000000e+00  
 Iyx Iyy Iyz 0.0000000e+00 3.3155975e+07 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 1.6809782e+07

INERTIA at CENTER OF GRAVITY with respect to \_INNERLID-WELD coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.6623346e+07 0.0000000e+00 0.0000000e+00  
 Iyx Iyy Iyz 0.0000000e+00 3.3155975e+07 0.0000000e+00  
 Izx Izy Izz 0.0000000e+00 0.0000000e+00 1.6623346e+07

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 1.6623346e+07 1.6623347e+07 3.3155975e+07

ROTATION MATRIX from \_INNERLID-WELD orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_INNERLID-WELD orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 5.0940234e+02 5.0940236e+02 7.1942019e+02 MM



## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART SMALL-RINGWELD

VOLUME = 1.5518159e+06 MM<sup>3</sup>  
 SURFACE AREA = 4.2412957e+05 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 1.3485280e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_SMALL-RINGWELD coordinate frame:

X Y Z 0.0000000e+00 8.3113665e+00 0.0000000e+00 MM

INERTIA with respect to \_SMALL-RINGWELD coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 4.2137356e+06 0.0000000e+00 1.9484745e-02  
 Iyx Iyy Iyz 0.0000000e+00 8.4246736e+06 0.0000000e+00  
 Izx Izy Izz 1.9484745e-02 0.0000000e+00 4.2137356e+06

INERTIA at CENTER OF GRAVITY with respect to \_SMALL-RINGWELD coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 4.2128041e+06 0.0000000e+00 1.9484745e-02  
 Iyx Iyy Iyz 0.0000000e+00 8.4246736e+06 0.0000000e+00  
 Izx Izy Izz 1.9484745e-02 0.0000000e+00 4.2128041e+06

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 4.2128041e+06 4.2128041e+06 8.4246736e+06

ROTATION MATRIX from \_SMALL-RINGWELD orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_SMALL-RINGWELD orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 5.5892772e+02 5.5892772e+02 7.9039932e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART IB-SUPPORT-RING-WELD\_

VOLUME = 9.4917986e+05 MM<sup>3</sup>  
 SURFACE AREA = 3.2389677e+05 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 8.2483730e+00 KILOGRAM

CENTER OF GRAVITY with respect to \_IB-SUPPORT-RING- coordinate frame:  
 X Y Z 0.0000000e+00 -6.6813769e+00 0.0000000e+00 MM

INERTIA with respect to \_IB-SUPPORT-RING- coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 2.3537922e+06 0.0000000e+00 -1.0964753e-02  
 Iyx Iyy Iyz 0.0000000e+00 4.7064807e+06 0.0000000e+00  
 Izx Izy Izz -1.0964753e-02 0.0000000e+00 2.3537922e+06

INERTIA at CENTER OF GRAVITY with respect to \_IB-SUPPORT-RING- coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 2.3534239e+06 0.0000000e+00 -1.0964753e-02  
 Iyx Iyy Iyz 0.0000000e+00 4.7064807e+06 0.0000000e+00  
 Izx Izy Izz -1.0964753e-02 0.0000000e+00 2.3534239e+06

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 2.3534239e+06 2.3534239e+06 4.7064807e+06

## ROTATION MATRIX from \_IB-SUPPORT-RING- orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_IB-SUPPORT-RING- orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 5.3415333e+02 5.3415333e+02 7.5537741e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART FLATLID-BOTTOM-WELD

VOLUME = 1.5795266e+06 MM<sup>3</sup>  
 SURFACE AREA = 3.5946382e+05 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 1.3726086e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_FLATLID-BOTTOM-W coordinate frame:  
 X Y Z 0.0000000e+00 1.3245253e+01 0.0000000e+00 MM

INERTIA with respect to \_FLATLID-BOTTOM-W coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 4.0543378e+06 0.0000000e+00 3.0704241e-01  
 Iyx Iyy Iyz 0.0000000e+00 8.1024692e+06 0.0000000e+00  
 Izx Izy Izz 3.0704241e-01 0.0000000e+00 4.0543380e+06

INERTIA at CENTER OF GRAVITY with respect to \_FLATLID-BOTTOM-W coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 4.0519297e+06 0.0000000e+00 3.0704241e-01  
 Iyx Iyy Iyz 0.0000000e+00 8.1024692e+06 0.0000000e+00  
 Izx Izy Izz 3.0704241e-01 0.0000000e+00 4.0519299e+06

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 4.0519295e+06 4.0519301e+06 8.1024692e+06

## ROTATION MATRIX from \_FLATLID-BOTTOM-W orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_FLATLID-BOTTOM-W orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 5.4332236e+02 5.4332240e+02 7.6830796e+02 MM

## Mass Properties of 21-PWR Waste Package

## MASS PROPERTIES OF THE PART TRUNNION-SKIRT-WELD

VOLUME = 4.2412249e+06 MM<sup>3</sup>  
 SURFACE AREA = 7.0579797e+05 MM<sup>2</sup>  
 DENSITY = 8.6900000e-06 KILOGRAM / MM<sup>3</sup>  
 MASS = 3.6856244e+01 KILOGRAM

CENTER OF GRAVITY with respect to \_TRUNNION-SKIRT-W coordinate frame:  
 X Y Z 0.0000000e+00 -1.4687079e+01 0.0000000e+00 MM

INERTIA with respect to \_TRUNNION-SKIRT-W coordinate frame: (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.0941792e+07 0.0000000e+00 -1.0746011e+00  
 Iyx Iyy Iyz 0.0000000e+00 2.1859782e+07 0.0000000e+00  
 Izx Izy Izz -1.0746011e+00 0.0000000e+00 1.0941792e+07

INERTIA at CENTER OF GRAVITY with respect to \_TRUNNION-SKIRT-W coordinate frame:  
 (KILOGRAM \* MM<sup>2</sup>)

## INERTIA TENSOR:

Ixx Ixy Ixz 1.0933841e+07 0.0000000e+00 -1.0746011e+00  
 Iyx Iyy Iyz 0.0000000e+00 2.1859782e+07 0.0000000e+00  
 Izx Izy Izz -1.0746011e+00 0.0000000e+00 1.0933842e+07

PRINCIPAL MOMENTS OF INERTIA: (KILOGRAM \* MM<sup>2</sup>)

I1 I2 I3 1.0933841e+07 1.0933843e+07 2.1859782e+07

## ROTATION MATRIX from \_TRUNNION-SKIRT-W orientation to PRINCIPAL AXES:

0.00000 1.00000 0.00000  
 0.00000 0.00000 1.00000  
 1.00000 0.00000 0.00000

ROTATION ANGLES from \_TRUNNION-SKIRT-W orientation to PRINCIPAL AXES (degrees):  
 angles about x y z -90.000 0.000 -90.000

## RADII OF GYRATION with respect to PRINCIPAL AXES:

R1 R2 R3 5.4466671e+02 5.4466676e+02 7.7013592e+02 MM

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT  
SPECIAL INSTRUCTION SHEET  
Complete Only Applicable Items

1. QA: QA  
Page: 1 of: 3

OK  
1-23-01  
n/c

This is a placeholder page for records that cannot be scanned or microfilmed

2. Record Date  
01/05/2001

3. Accession Number

ATT-TO MOL. 20010123.0122

4. Author Name(s)  
ADAM K. SCHEIDER

5. Author Organization  
N/A

6. Title  
HORIZONTAL DROP OF 21-PWR WASTE PACKAGE

7. Document Number(s)  
CAL-UDC-ME-000009

8. Version  
REVISION 00

9. Document Type  
DATA

10. Medium  
CD-ROM

11. Access Control Code  
PUB

12. Traceability Designator  
DC #26007

13. Comments  
THIS IS A SPECIAL PROCESS CD-ROM AS PART OF ATTACHMENT III, AND CAN BE LOCATED THROUGH THE RPC

**OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT  
ELECTRONIC SOURCE FILE VERIFICATION**

QA: N/A

## 1. DOCUMENT TITLE:

Horizontal Drop of 21-PWR Waste Package

## 2. DOCUMENT IDENTIFIER:

CAL-UDC-ME-000009

## 3. REVISION DESIGNATOR:

Rev 00

**ELECTRONIC SOURCE FILE INFORMATION**

## 4. ELECTRONIC SOURCE FILE NAME WITH FILE EXTENSION PROVIDED BY THE SOFTWARE:

see attached

## 5. DATE LAST MODIFIED:

January 05, 2001

6. ELECTRONIC SOURCE FILE APPLICATION:  
(I.E., EXCEL, WORD, CORELDRAW)

Word, Power Point

## 7. FILE SIZE IN KILOBYTES:

see Attached

## 8. FILE LINKAGE INSTRUCTIONS/INFORMATION:

normal

## 9. FILE CUSTODIAN: (I.E., DC, OR DC APPROVED CUSTODIAN)

DC

## 10. FILE LOCATION FOR DC APPROVED CUSTODIAN (I.E., SERVER, DIRECTORY)

~~n/a~~ OPDD 1-9-2001 aa

## 11. PRINTER SPECIFICATION (i. e., HP4SI) INCLUDING POSTSCRIPT INFORMATION (I.E., PRINTER DRIVER) AND PRINTING PAGE SETUP (I.E., LANDSCAPE, 11 X 17 PAPER)

HP5si, Portrait for all, except Attachment I is landscape, HP5mc for color pages

## 12. COMPUTING PLATFORM USED: (I.E., SUN)

IBM Compatible

## 13. OPERATING EQUIPMENT USED: (I.E., UNIX, SOLARIS)

PC

## 14. ADDITIONAL HARDWARE/SOFTWARE REQUIREMENT USED TO CREATE FILE(S):

n/a

## 15. ACCESS RESTRICTIONS: (IF ANY)

n/a

**COMMENTS/SPECIAL INSTRUCTIONS**

16.

none

**CERTIFICATION**

## 17. NAME (Print and Sign)

Adam K. Scheider Adam K. Scheider

## 18. DATE:

JAN 05, 2001

## 19. ORGANIZATION

FCF

## 20. DEPARTMENT

Waste Package

## 21. LOCATION/MAIN STOP

MS 423

## 22. PHONE

295-4602

**DC USE ONLY**

## 23. DATE RECEIVED:

01-08-2001

## 24. DATE REVIEWED:

01/11/2001

## 25. DATE FILES TRANSFERRED:

01-09-2001

## 26. NAME (Print and Sign):

TRUDY JOHNSON

## 27. DATE:

01/11/2001

**maxell****CD-R 650MB 74 MIN.**

CD-Recordable

Disque Compact Enregistrable



File	Size	Date	Time
Att I.ppt	501 KB	11/13/2000	11:32 AM
Att II.doc	135 KB	11/13/2000	11:20 AM
cel ME9r00.doc	619 KB	01/05/2001	10:54 AM
Page 1.tif	8,680 KB	01/05/2001	4:53 PM